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ABSTRACT

The handbook addresses the assessment of student performance and the establishment of criteria by which to measure student progress in six domains within science: (1) Concepts; (2) Processes; (3) Applications; (4) Attitude; (5) Nature of Science; and (6) Creativity. Each domain is defined, and a rationale is provided for assessing student learning in that domain. Following the descriptive section, examples of assessment instruments, including multiple choice, essay, and alternative forms of assessment are provided. Suggestions are made to help teachers improve and enhance their assessment strategies. Chapter 1 introduces the handbook, and Chapter 2 contains suggestions for getting started. Chapter 3, "Six Domains of Science," describes the six domains. Chapter 4, "Assessment in the Contexts of Teaching," discusses the use of current types of assessment and their relation to the National Science Education Standards. In Chapter 5, "Evaluating Teaching Practice," techniques to help teachers improve their practices, including videotape and journals, are discussed. Chapter 6, "Rubrics," considers scoring assessments. Chapters 7 through 10 present assessment samples for all grades and for grades kindergarten through 4, 5 through 8, and 9 through 12. A glossary is included. (Contains 3 figures, 26 tables, and 99 references.) (SLD)

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The Iowa Assessment Handbook

Editors:

Sandra K. Enger & Robert E. Yager

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TENETS FOR ASSESSMENT

Assessment as learning...

- Assessment design is guided by the purpose of the assessment.
- Assessment includes multiple measures that are used to inform instruction.
- Pre-assessment of student understanding is vital in determining pre-conceptions and should be completed and documented by the teacher prior to the introduction of each new concepts.
- Evidence of student learning is documented throughout the year.
- Assessment provides information about what the student CAN do rather than what the student cannot do.
- Assessment is viewed in terms of the "growth" of each student.
- Students are assessed both on an individual basis and on their involvement in group work.
- Assessment tasks should be meaningful, challenging, and engaging throughout instructional activities.
- Assessment tasks are set in a context that is "real world" and should have relevancy for the student.
- Central to any assessment scheme are process skills, concepts, attitudes, creativity, understanding the nature of science, and applications to the real world.
- Process skills and cognitive behaviors are assessed throughout learning or instructional activities rather than at the completion of a unit or chapter.
- Responsibility for assessment is shared with the students.
- Assessment is implemented throughout each lesson and includes all student activities that relate to the six domains of science.
- Outcomes of various student assessments, including student interest, direct and drive instruction within learning situations.

ACKNOWLEDGMENTS

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PREFACE

Today, teachers have more responsibility in setting educational goals and developing ways to help students attain these goals. Assessment has become an important part of the teacher's professional practice. Teachers make decisions about how to interact with their students at the rate of one out of every two to three minutes, and they base those decisions on their own assessment of student learning (Stiggins, 1994). Because of the importance to the instructional process, assessment is a major concern in education today.

Assessment, integrated with instruction, can provide a solid basis for restructuring science education. Classroom assessment practices have often focused on the use of set questions which have provided a limited number of options for student responses. Recent perceptions of assessment view assessment as a pathway to address the following questions:

- Should assessments tell us what students cannot do or what each student can do?
- Should assessments set goals for learning, or merely sample the present curriculum?
- Should students be judged only on their individual work, or also on their ability to work together for the benefit of a larger group?
- How can assessment encourage and recognize inventive, imaginative responses that, although unexpected, are constructive and appropriate?
- To what extent can students evaluate data, understand concepts, demonstrate process mastery and apply what has been learned to new situations?
- How does one assess that each student can actually do what the instruction intends for him/her to do? What evidence is used to document this assessment?
- What can be done to help students become better learners?
- How can students attain the desired level achievement?

These questions are important for teacher educators, teachers, students, parents, and administrators. Each group has important questions that assessment of learning in the classroom can address. The function of assessment is to provide answers to the above questions. Assessment can be a powerful tool for reform, since changing the nature of assessment can lead to changing the nature of instruction (Raizen & Kaser, 1989).

Effective educational programs are linked to assessment schemes that help **individual** students grow, develop, and succeed. Such assessment schemes should be carefully designed to meet mutually shared or stated instructional goals of the teacher and the learner. Provided that various assessments of student learning are meaningful, they should serve as an impetus for the improvement of school programs.

This handbook addresses the assessment of student performance and the establishment of criteria by which to measure student progress in six domains within science: Concepts, Processes, Applications, Attitude, Nature of Science, and Creativity. Each domain is defined and a rationale is provided for assessing student learning in that domain. Following the descriptive section, examples of assessment instruments, including multiple choice, essay, and alternative forms of assessment are provided.

Many ideas are suggested for use by teachers to improve and enhance their assessment strategies. Teachers are encouraged to explore the ideas contained in this handbook and develop their own models for assessment. This edition of the handbook is based on materials included in previous editions and utilizes suggestions from Iowa Scope, Sequence, and Coordination Project teachers and submissions from other users of the handbook.

CHAPTER 1: INTRODUCTION

When humans use scientific knowledge and technology, global awareness becomes critical for environmental protection. As the American Association for the Advancement of Science (AAAS) announced in Science for All Americans (Rutherford & Ahlgren, 1990, p. vi)

> *What the future holds in store for individual human beings, the nation, and the world depends largely on the wisdom with which humans use science and technology. But that, in turn, depends on the character, distribution, and effectiveness of the education that people receive.*

Accordingly, scientific literacy has become a major goal of science education. Although there is no consensus regarding what kinds of science content are necessary for scientific literacy, a scientifically literate person is believed to be one who appreciates the strengths and limitations of science and knows how to use scientific knowledge and scientific ways of thinking for living a better life and for making rational social decisions.

The Iowa-Scope, Sequence, and Coordination (Iowa-SS&C) Project worked to promote scientific literacy in striving to meet the goals listed below through the use of science-related societal issues and students' previous experiences. The teaching goals of the Iowa-SS&C Project have been to work toward the development of:

1. student ability to inquire;
2. student understanding of content;
3. student ability to apply what is learned to new contexts; and
4. student understanding of the nature of science.

The Iowa-SS&C Project placed emphases on student learning in six domains of science which included 1) Concepts, 2) Processes, 3) Applications, 4) Positive Attitudes, 5) Creativity, and 6) the Nature of Science.

A holistic assessment approach is required to assess student learning in the six domains. While standardized tests may be valid in measuring knowledge of facts, they may lack validity in measuring higher-level thinking processes, investigation skills and practical reasoning (Aikenhead, 1973; Champagne & Newell, 1992). This is not to say that standardized tests cannot and do not measure higher-level thinking processes. The deeper issue involved is one of having the assessments align with instruction and intended student outcomes. Multiple measures of what students know and can do as a result of their learning experiences are desired, and the use of a multifaceted assessment approach has the potential to provide a better profile of student understanding. A more holistic assessment approach deals with the "whole student" (Raizen & Kaser, 1989) and is an attempt to assess a variety of student abilities related to science in different contexts.

Traditionally, assessment has been primarily a feedback system used to inform students as to how they are learning and to inform teachers for decision-making about the effectiveness of classroom instruction. Assessments have been viewed as inert measuring

instruments, like thermometers, which could be dipped into a school and taken out without having any profound influence on the school. But assessments do influence schools, and teachers may teach to tests, knowing that their teaching effectiveness may be judged by their students' scores. Thus, assessment modes can have a profound influence on teaching, often limiting classroom activities to exercises that will be on the tests (Champagne & Newell, 1992). If teachers are compelled to teach to the tests, then the tests should emulate the desired student learning outcomes.

The current focus on assessments stresses the necessity to link instruction and learning with assessment. Assessment should be used as a tool for communicating expectations of the science education system to those concerned with science education (NRC, 1996). Accordingly, assessments should be embedded in the learning context to help and guide student understanding on the way toward a cumulative assessment. Some important elements for embedding assessment into teaching contexts are emphasized in The Iowa Assessment Handbook. These elements include the following components fostered by the teacher: the invitation of student involvement in the development of assessments; the encouragement of students to self-assess; and the empowerment of students to take responsibility for their own learning.

The shift from teacher-centered instruction to more student-centered learning may be challenging for both teachers and students. Teachers must adjust teaching practices to include a variety of instructional strategies and should consider teaching/learning environments that move students toward the goal of becoming self-directed learners. The National Research Council (NRC) has provided some assessment examples and procedures in the National Science Education Standards (NRC, 1996). The standards state that the assessment process is comprised of the following components:

1. data use;
2. data collection;
3. methods to collect data; and
4. users of data.

These four components are interrelated and are used for making decisions and taking action based on the data. The National Science Education Standards (NRC, 1996) include the following assessment standards:

- Standard A: Assessments must be consistent with the decisions they are intended to inform.
- Standard B: Achievement and opportunity to learn science must be assessed.
- Standard C: The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.
- Standard D: Assessment practices must be fair.
- Standard E: The inferences made from assessments about student achievement and opportunity to learn must be sound.

CHAPTER 2: GETTING STARTED

The Iowa Assessment Handbook has been developed for and by teachers as they have used additional assessment strategies with their teaching activities. The ultimate value of this handbook depends upon its use as a tool, as a reference, and as a starting point for communication.

As a Tool

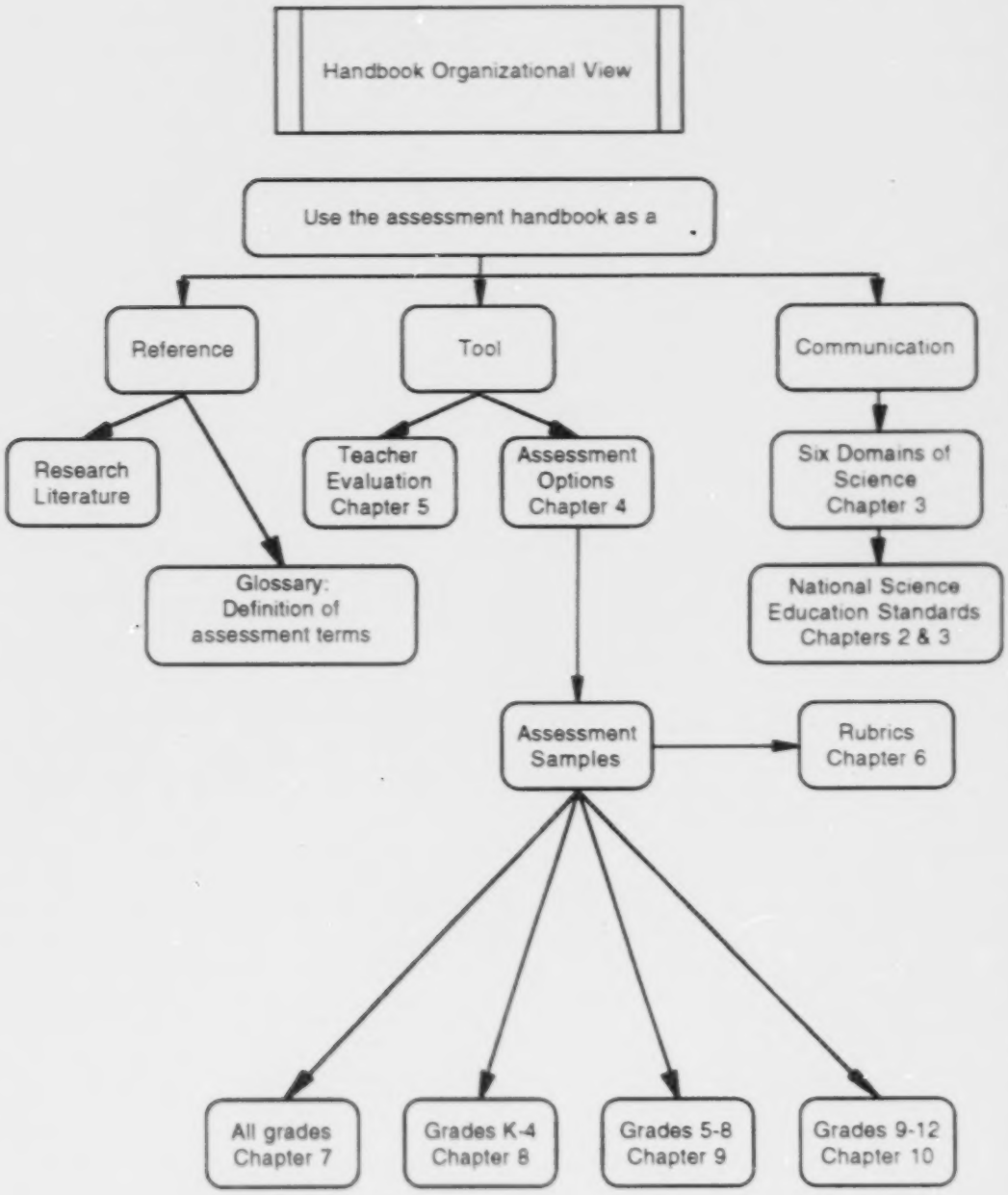
* The assessment handbook has been designed to promote the use of assessment design ideas and examples.
* Teachers may see areas of the curriculum they have overlooked and can find ideas for improvement in the **Teaching Practice Evaluation** section.
* **Examples** created by practicing teachers are provided. These ideas can provide insight into how other teachers evaluate their students' learning.
* Assessment samples are organized within grade-levels which correspond to those used in the National Science Education Standards. (**K-4**, **5-8**, and **9-12**).
* The **Glossary** provides a sampling of assessment-related terminology.

As a Reference

* No assessment is perfect. Think of the assessment handbook as a reference, not a cookbook, to improve assessment practices in the science classroom where reform and change are occurring.
* For further research, the **Reference** section is provided. The handbook is a starting point, not the end, for the process of enhancing assessment strategies. The reference list represents only a sampling from the extensive assessment literature.

As a Communication

* While the **Introduction**, **Rationale** and **Six-domains** sections may enhance your assessment ideas, you are invited to provide input and make recommendations for improvements for future editions.
* The Iowa Assessment Handbook may also serve as a vehicle for communication among you and your colleagues about what STS and SS&C are and how they exemplify current efforts in science education reform.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CHAPTER 3: SIX DOMAINS OF SCIENCE

Science is multifaceted. For many decades, one of these facets, content (concepts), has been stressed as the sole expression, dimension, or view of science. Very often, this has been labeled "teaching from the text" where the textbook has served as the guide for the content to be delivered. Scientists and teachers of science would agree that science involves much more than knowing content. Most science educators agree that assessment of student performance should include other facets of learning in science in order to illustrate a more inclusive and representative picture of what science is.

In an attempt to capture the "whole" and/or "authentic" picture of students' work, the Iowa-SS&C Project defined six domains of science as a rationale for assessing student learning in science. The six-domains of science include: Concept, Processes, Applications, Attitudes, Creativity, and Nature of Science. This broadened view of science is more consistent with both the National Science Education Standards (NRC, 1996) and the Benchmarks for Science Literacy (AAAS, 1993).

I. Concept Domain

Research Statement:

> Without these concepts it would be nearly impossible for a student to follow much of the public discussion of scientific results or public policy issues pertaining to science and technology (Millar, 1989).

A component of any science instruction involves a concern for science concepts which students learn. Student understanding of these concepts is crucial to successful teaching and learning. Millar (1989) noted that "without these concepts it would be nearly impossible for a student to follow much of the public discussion of scientific results or public policy issues pertaining to science and technology."

According to Thagard (1992), conceptual systems are primarily structured via *kind* or *is-a* hierarchies (i.e., Tweety is a canary, which is a kind of bird, which is a kind of animal, which is a kind of thing) and *part-whole* hierarchies (i.e., a toe is part of a foot, which is part of a leg, which is part of a body). Therefore, helping students construct the natural world in their own categorization in terms of scientific knowledge is one of the basic functions of science education. To do this, students' prior knowledge should be the starting point from which to construct understanding of scientific concepts. The "concrete before abstract" is a message that educators should strongly consider for informing teaching practice in the classroom. Students need to have experience with concepts on a concrete plane before moving to abstractions. Students need opportunities to try and to do- not just read about science. The evidence that science concepts have

been learned is provided most strongly when students use them in a real life or real world situation (NSTA position statement on STS, 1982).

Science in the classroom has been viewed and practiced for decades as a body of knowledge or facts to be learned or absorbed by students. Classically, this occurs by memorization of facts and concepts from a textbook. Knowledge and facts of science are clearly important and indeed necessary, but to memorize these facts as a sole purpose of science education violates the spirit of the very nature of science itself. This issue will be addressed further in the nature of science section.

What does the concept domain include? Yager & McCormack (1989) include the following under the umbrella of the concept domain:

- facts,
- laws (principles),
- theories, and
- internalized knowledge of students.

These are the currently accepted scientific constructs related to all of the sciences. When students have been engaged in science learning, they may need to know and understand particular concepts which can in turn be linked to other related concepts. This can be an emergent process facilitated by the teachers. The Iowa-SS&C Project argued that it was necessary for teachers to help arrange the "must-know" concepts for students through a well sequenced curriculum. Concept mastery is an essential aim --- but only when a meaningful context has been established. Both the Benchmarks for Science Literacy (AAAS, 1993) and the National Science Education Standards (NRC, 1996) provide recommendations about content and concepts. The research literature is replete with information relative to conceptual understanding in many science areas.

II. Process (skills) Domain

Research Statement:

> Knowledge of the process of constructing and communicating new scientific representations has the potential to yield important insights for science education. An individual scientist or group must learn how to construct a particular kind of representation of a domain and then must instruct the rest of the community in the new representation (Nersessian, 1989).

The investigative processes require hands-on/minds-on activities, laboratory inquiries, and experiments which provide the most powerful approach for helping students understand scientific concepts. These processes, often designated as inquiry skills, are embodied in the terms "exploring and investigating". A study in California (Shavelson, Baxter, & Pine, 1992) found that students with experience with hands-on

activities can reliably note their own progress in laboratory activities. More importantly, these inquiry skills are also necessary for dealing with everyday life and in developing an understanding of the natural world (Aikenhead, 1979). Thus, it is perhaps most important that these skills are set in situations in which the students can relate them to their personal experiences so inquiry skills are seen as "connected" rather than separate entities (SS&C Tenets). The use of process skills in a variety of contexts is important for developing an understanding of the nature of science.

The concept domain includes processes of science identified by AAAS in the development of Science: A Process Approach (SAPA). The 13 processes identified by AAAS represent a generally accepted set of processes which scientists use as they accomplish their work. These processes include:

- Observing;
- Using space/time relationships;
- Classifying, grouping and organizing;
- Using numbers, quantifying;
- Measuring;
- Communicating;
- Inferring;
- Predicting;
- Controlling and identifying variables;
- Interpreting data;
- Formulating hypotheses;
- Defining operationally;
- Experimenting.

The process skills can be targets for instruction themselves, but the identification of separate and distinct processes does not mean they always occur in definable and/or identifiable ways. Scientists and students may use several of the science process skills in concert, and these skills may be employed during scientific investigations in ways not expected or predicted by anyone observing the investigative process.

The idea that observation is theory-laden may not have been overtly discussed or considered by students. "**Observation is theory-laden**" means that what a person can see depends on what he or she believes (Abimbola, 1983). Personal viewpoints and creativity play roles in any investigation. This sends an implication that the beginning point for investigation should be based on student ideas and questions. Such ideas come from students' prior scientific knowledge, deduction, or even personal guesses and creativity.

In the hypothetico-deductive model, a hypothesis always precedes any investigation, and a conclusion of an investigation results from the confirmation of any hypotheses in mind, not from the data collected but from observation (Popper, 1991). Accordingly, doing science for students in a laboratory or investigation should involve a test of student ideas, not just to determine the "right" answers. This also sends a message to teachers to consider moving beyond only confirmation-type laboratory work.

Science teachers do need to play a role as the advocate of current "public concepts", i.e., the current accepted scientific thought, to challenge student "private thought" (Matthews, 1994), or to "persuade" (Kuhn, 1962) or convince a student to appreciate the current, prevalent interpretation/explanation of natural phenomena. Group discussion for an investigation may produce the same persuading effect (Johnson & Johnson, 1983). Students who understand the role of process skills in scientific

investigations may more often see science as a career that is fun and creative. These processes and skills are embedded in the knowing, doing, and thinking in science.

III. Application Domain

Research Statement:

> Application items measure understanding because students must do something on their own. That is, the students must demonstrate that they not only grasp the meaning of the information and processes, but that they can also apply it to concrete situations that are new to them. Thus, application items determine the extent to which students can transfer their learning and use it effectively in solving new problems (Gronlund, 1988).

A key question in the application domain is to determine the extent to which students can transfer and use effectively what they have seemingly learned to a new situation, especially in their own daily lives (Gronlund, 1988). The students must demonstrate that they not only grasp the meaning of the information and processes, but that they can also apply them to concrete situations that are new to them. Thus, the application domain is most important because it involves students using concepts and processes to solve a new problem. Students who can "apply" what they have learned to new situations provide evidence that they understand a concept.

Two major frameworks that students use for applications are the school and everyday life. In school, application often involves problem solving or learning new material by using knowledge and skills acquired in previous studies. In everyday life, the crucial factor appears to be the ability to choose the concepts and skills pertinent and relevant for dealing with novel situations. Some dimensions of the application domain are:

- Use of critical thinking;
- Ability to connect instances of scientific concepts in everyday life experiences;
- Application of learned science concepts and skills to everyday technological problems;
- Understanding of scientific and technological principles involved in common technological devices;
- Use of open-ended questions;
- Use of scientific processes in solving problems that occur in everyday life;
- Understanding and evaluation of mass media reports on scientific developments;
- Decision-making related to personal health, nutrition, and life style based on knowledge of scientific concepts rather than on hearsay or emotions;
- Integration of science with other subjects (interdisciplinary);
- Integration of the sciences (intradisciplinary).

The Iowa-SS&C Project stressed the association of scientific knowledge with students' social and living experiences through the use of current social issues to assist students in seeing the need for intermission and skills. Beginning science learning based upon the concerns in the "real" world may be a way to diminish the learning gap between the two worlds of the school-science experiences and the personal technology experiences (Yager & McCormack, 1989). An issue-based approach to science learning can be a potent vehicle for engaging students in learning that is local, personal, and relevant.

IV. Attitude Domain

Research Statements:

> Students who were induced to make positive statements about themselves attained a more positive attitude about themselves (Felker, 1974).

> Teachers who reflect an active and personal interest in their students' progress and who show it are more likely to be successful in enhancing students' confidence in themselves (Page, 1958).

Attitude is very broadly used in discussing issues in science education and is often used in various contexts. Two broad categories are distinguishable: attitude toward science (e.g., "interest in science", "attitude toward scientists", or "attitudes toward social responsibility in science") and scientific attitude, (i.e., "open-minded", "honesty", or "skepticism") (Gardner, 1975).

A major aim of the Iowa-SS&C Project has been to counter the typical and continuous decline of attitudes toward science associated with more years of schooling. Attitudes can serve both as an outcome of science learning (a dependent variable) and as a factor which affects learning (an independent variable). The attitude domain includes:

- Development of more positive student attitudes toward science in general;
- Development of positive attitudes toward oneself (an "I can do it" attitude);
- Exploration of human emotions;
- Development of sensitivity to, and respect for, the feelings of other people;
- Expression of personal feelings in a constructive way;
- Decision-making about personal values;
- Decision-making about social and environmental issues.

The positive "I CAN" attitude and "I ENJOY" feelings may enhance students' efforts to seek answers for their own problems and lessen their reliance on others.

Students should be able to solve problems with greater independence, that is, without parent or teacher intervention. Statements such as, "don't tell me the answer," or "I can figure it out all by myself," should indicate a growing autonomy. The end result of this self-directed growth could very well be a voluntary acceptance and responsibility for life-long learning.

V. Creativity Domain

Research Statement:

> Creativity is integral to science and the scientific process. It is used in generating problems and hypotheses and in the development of plans of action (Hodson & Reid, 1988).

Torrance (1969) defined creativity as

> *"...the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and re-testing these hypotheses and possibly modifying and re-testing them; and finally communicating the results."*

Creativity plays an integral role in the many processes of science and in doing science. Creativity is a complex construct, difficult to assess, and rests very often in what might be called "recognizing it when you see it." It is almost as if creativity is a free-spirit. If a science educator wishes to foster a classroom that enhances students' creativity, this sends a message that the classroom should probably become more student-centered. Creativity is fostered and nurtured through a richness in experience. Creativity calls for an openness in the classroom, an acceptance of ideas, a try new things approach, and a so-called go with the "flow" approach. In fact, Csikszentmihalyi (1990; 1996) uses "flow" as descriptive of the state in which creativity is turned on in individuals.

Studies have suggested that the work done in the laboratory rests on the ability to manipulate the objects and the instruments employed. Three features of laboratory practice make the need for creative abilities paramount. First, scientists and students do not work with the natural world *as it is*, but rather manipulate the objects of study to make them more accessible for experimentation. Second, investigators do not work with the natural world *where it is*, but are instead able to bring those natural objects into an artificial setting (i.e., the laboratory, the classroom, on a slide, etc.). Third, scientists and students do not need to study an event *only when it happens*, but rather can cause the event to occur unnaturally when the situation demands it (Knorr-Cetina, 1992). These three characteristics of a laboratory require an imaginative, inventive mind capable of performing these investigations. These aspects of the scientific enterprise are often ignored in the traditional classroom; yet, they are integral to science instruction.

Scientific activities related to the creativity domain include:

- Visualizing- producing mental images;
- Combining objects and ideas in new ways;
- Finding alternate or unusual uses for objects;
- Solving problems and puzzles;
- Designing devices and machines;
- Producing unusual ideas;
- Merging;
- Diverging.

The Iowa-SS&C teaching strategies stress the role of guessing as an element of creativity and suggest that students even give wild guesses or hypotheses to provide a diversity of perspectives in seeing the same natural phenomena. This can stimulate student creativity and interpretation of results (Yager & McCormack, 1989). Further, creativity is required as questions about the natural world are posed, explanations provided, and tests devised.

VI. The Nature of Science

Research Statement:

> Pre-service or in-service courses emphasizing the nature of science (e.g., use of articles, discussions, activities, curriculum projects and audiovisual materials) can result in significant gains in teacher scores on instruments designed to measure understanding of this concept (Akindehein, 1988; Barufaldi, Bethel, & Lamb, 1977)

As noted in Science for All Americans (AAAS, 1990):

> *Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting, and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing. (p. 3)*

How scientific knowledge has developed and the roles scientists have played during such a process are two fundamental aspects that are considered important for students to know. Raising student awareness and a development of an understanding of these aspects should be included in science learning. Science itself is dynamic, and, as witnessed by history, many ideas have come and have been replaced or discarded. Many science educators

suggest that instruction in a science classroom should reflect this nature, i.e., the tentativeness of scientific knowledge (Lederman, 1992).

However, the fact that scientific knowledge is tentative has two facets which should be expressed explicitly in working with students. First, the purpose of science is to develop a systematic knowledge to understand how nature behaves. Students should see science as a human endeavor in which scientific knowledge is developed by humans in an attempt to make sense of the world. Accordingly, scientific knowledge is not a truth "to be discovered" in the natural world, but a man-made explanation. Second, scientific knowledge can be changed, shifted (Kuhn, 1962) from one point of view to the other due to the external social influences such as politics, economics, and culture. This suggests that the scientific knowledge is not absolutely objective. Therefore, the understanding of the involvement of social factors in scientific development provides another purpose for science education.

Science, accompanied by the power of technology, has unique characteristics which impact society. Perhaps no other human activities have ever played such a role in shaping the directions in which societies have moved. The potential to do good is very often offset by the power to cause harm, and long term outcomes and effects are not always predictable.

An important aspect of the nature of science is related to how scientists think and work in the scientific community. Helping students to understand more of the nature of science can promote deeper understanding of what it means to do science. Science is often portrayed as a major intellectual pursuit of truth. From that expectation, many people view scientists as a group of people who are more objective and intelligent than others. Students often believe that scientists can solve problems merely based on their scientific knowledge. Science is a human activity which engages real people.

In doing science, scientists often work collaboratively, and given the specializations in science and related areas, a team approach is very often needed to work on problems. Seldom do scientists work in isolation; a laboratory involves a team of people. In order to ask questions and work at finding solutions to problems, scientists must both share and obtain information from others in their field, and most importantly, they must reach a consensus by virtue of discussion and persuasion, not just on the basis of mere evidence. Peer review is an important component of doing science, and scientists expect to be challenged and defend the work they have done. The work that scientists do must be replicable, in that others can verify the work. Science is also a very competitive venture which includes the competitive elements: being first to report findings; competing for research money; status within the scientific community; status for a university.

Science instruction in the classroom should attempt to portray the nature of the discipline—not simply a study of the information/interpretation included in the textbook. Views currently held as "truths of science" have changed and will continue to change throughout time. Therefore, teaching only for the retention of facts without grounding them in "real" world experiences will only, sooner or later, result in the loss of these facts from memory. In an attempt to reflect the nature of science, group work, reporting findings, discussion, and reaching consensus are all parameters involved with the nature of science domain.

The nature of science domain should build understandings of:

- the ways in which scientific knowledge is created; the nature of research processes
- the meaning of basic concepts of scientific research (e.g., hypothesis, assumption, control, replication);
- the ways scientists work and their organization;
- the interactions among science, economy, politics, history, sociology, philosophy;
- the history of scientific ideas;

CHAPTER 4: ASSESSMENT IN CONTEXTS OF TEACHING

Traditional assessments may not fulfill the intended goals of current science education reform which embody the view that learning is an active process (Ausubel, 1968) and that scientific knowledge is meaningful to students only when they have opportunities to learn it through inquiry[1] (NRC, 1996). With such an interactive picture of student learning in mind, current science educators argue that student performance in science should be assessed from various facets of learning in different contexts of teaching. Performance assessments have been added and/or reconsidered for use in an effort to provide multiple measures of student learning outcomes. The National Science Education Standards (NRC, 1996) have set out assessment standards that can be used to expand and enhance assessment practice. The Association for the Education of Teachers in Science (AETS) is currently developing a set of assessment standards which communicate expectations about assessment practices that should be addressed in the preservice education programs of science teachers.

The National Council on Measurement in Education (NCME) has also set out the Code of Professional Responsibilities in Educational Measurement (NCME, 1995). This code is informational for persons involved in various assessment-related uses. Numerous educational measurement books and other resources from organizations such as the regional educational laboratories also provide an excellent source of assessment references ranging from theory to practice.

In this chapter, current assessment types and methods will be reviewed; the outlines of assessments in the National Science Education Standards will be introduced; and ways of applying assessment standards in practice will be addressed.

A. ASSESSMENT TYPES AND METHODS

Recently, there has been a growing interest among science educators in authentic assessment which includes multiple forms of assessment to ascertain what students know and can do as a result of their science learning experiences. Various kinds of performance assessments and portfolio assessment may be used in concert with more traditional assessments, since a concern exists that the more traditional standardized tests cannot represent a complete picture of student performance in science (Pierce & O'Malley, 1992; Champagne & Newell, 1992). However, few would deny that standardized tests are indicators of some facets of student achievement, especially in large scale testing, and should not necessarily be discarded from assessment options. Information from large studies such as the Third International Mathematics and Science Study (TIMSS) and the National Assessment of Educational Progress (NAEP) can provide assessment information that can at least raise questions about the nature of programs and what students are expected to be able to do.

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[1] "Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world." (NRC, 1996).

I. Standardized Assessment

Definitions:

A standardized assessment is standardized in the sense that the administration procedures, directions, apparatus, and scoring are fixed by the constructors so that the test may be administered and scored identically by different examiners in different settings to achieve comparable results across all examinees (Airasian & Terrasi, 1989). Often, a standardized test refers to paper-pencil multiple-choice test.

Advantages of Multiple-Choice Testing:

1) It is less inexpensive than some other of testing and easier to administer to large numbers of students (Champagne & Newell, 1992).

2) It is efficient to use to rank individuals. Also, the scores of standardized tests can readily be used to make comparisons across locations, cities, states and nations (Champagne & Newell, 1992).

3) It is a fast tool to test student knowledge of specific content, such as the definition and recall, but it is only a good indicator to represent student knowing in the scope of "that test" and no further inferences should be made (Aikenhead, 1973).

4) It is possible to sample from a wide variety of learning targets (Nitko, 1996).

Disadvantages of Multiple-Choice Testing:

1) Generally, a multiple-choice test is constructed upon the assumption that knowledge can be represented by an accumulation of bits of information and that there is one right answer. From the discussion in the section of the Nature of Science, it should be noted that there is no absolute truth about the natural phenomena in terms of human knowledge; i.e., there is more than one possible interpretation, but not one right answer.

2) The uses of standardized tests have profound effects on teaching; teachers do teach to tests and schools are ranked based on test information. Also, many researchers think that multiple-choice tests fail to assess higher-order skills, such as open-ended problem solving, and other skills essential for functioning in school or work settings (Haney & Madaus, 1989; Neill & Medina, 1989; O'Neil, 1992; Wiggins, 1989). Using the scores from standardized tests to represent student performance provides an incomplete picture of student learning. The alternative side to this argument could be made as well that multiple-choice tests can measure higher-order thinking skills and information beyond recall.

3) Multiple-choice tests may reflect the activities and discussions students typically encounter in classrooms. In addition, multiple-choice tests do not reflect current theories of learning and cognition and are not based on abilities students actually need for future success (Herman, 1992).

4) Another concern is that standardized tests cannot be used to closely monitor student progress in the school curriculum throughout the year because they are only administered once or twice annually (Champagne & Newell, 1992).

II. Alternative Assessment

According to (Pierce & O'Malley, 1992) alternative assessment is:

1) any method of finding out what a student knows or can do that is intended to show growth and inform instruction and is not a standardized or traditional test;

2) by definition a criterion-referenced test, but not norm-referenced test;

3) authentic because it is based on activities that represent actual progress toward instructional goals and reflect tasks typical of classrooms and real-life settings; and

4) inclusive of teacher observation, performance-based assessment, and student self-assessment, etc.

Alternative assessment enables the evaluation of a wide variety of valued outcomes. By taking advantage of the "teach-to-test", it promotes the use of instructional time spent developing these wide-ranging skills and also provides more information about each student's knowledge and skills. Further, it is possible to begin to profile an individual's intellectual development over time. A major weakness of alternative assessment is the lack of consistency of interpretation of results which is part of the reason for not having been widely used (Champagne & Newell, 1992). Alternate assessments are also subject to reliability and validity questions, can be time consuming to score, and call for some very subjective judgments. With any assessment the underlying **purpose** for conducting the assessment should guide the assessment design and the use of the results.

A recommendation for classroom teachers would be to use multiple measures to assess the cognitive development and academic progress of students. Possibilities for integrating assessment with instruction, assessment of learning processes and higher-order thinking skills, and a collaborative approach to assessment enables teachers and students to interact in the teaching/learning process.

1. Performance-Based Assessment

According to Pierce & O'Malley (1992), performance-based assessment:

1) is viewed as an alternative assessment;

2) often calls for a performance task in which a student demonstrates specific skills and competencies: for example, in laboratory practices, in relation to a continuum of agreed upon standards, such as a set of rubrics to indicate proficiency or excellence; and

3) reflects student performance on instructional tasks and relies on rater judgment in design and interpretation. During the task presentation, the

evaluator can provide feedback, evaluation, and support as needed to improve student learning.

Advantages of Performance-Based Assessment:

1) It can enhance student inquiry skills in the laboratory;

2) It can provide more opportunities for students to work on open-ended questions, and thus promote their abilities for critical thinking;

3) It can promote student abilities to think and work collaboratively in groups and teams.

Implications of Performance-Based Assessment:

Performance assessments can be administered to groups of three or four students. Authentic tasks are often complicated since it is unlikely that one student alone would have the skills, time, and motivation to do them well. Secondly, the use of group work is becoming increasingly important in the science curriculum (Champagne & Newell, 1992).

2. Portfolio Assessment

Definitions of Portfolio Assessment:

Portfolio assessment according to (Pierce & O'Malley, 1992):

1) is the use of records of a student's work over time and in a variety of modes to show the depth, breadth, and development of the student's knowledge, skills and attitudes;

2) is the purposeful and systematic collection of student work that reflects accomplishments relative to specific instructional goals or objectives;

3) provides an approach for combining the information from both alternative and standardized assessments; and

4) includes the key elements of student reflection and self-monitoring.

Advantages of Portfolio Assessment:

1) It helps students to develop self-assessment strategies that will be useful in all domains.

2) It shows and monitors the evidence for student growth.

3) It is sensitive to context; different age levels and different science domains will elicit a range of choices about what to enter into the collections.

Implications of Portfolio Assessment:

The portfolio can be a folder, a bin, or a shoe box that contains dated work from each student throughout the week, month, unit, or year. The portfolio contents, which could include lab reports, journal entries, research papers, and similar

student products, are determined by criteria established by the teachers and students. A collaborative approach allows students to take part in and see the results of their own growth over time. Janet Dunkel of Charles City, Iowa, had used four different types of portfolios and has provided examples of what she assesses in her classroom:

1. **Collection Portfolio:** A wide variety of work viewed by the teacher and student.

2. **Student's Showcase:** Best work, shows growth—viewed by parent and can be put on public display.

3. **Teacher/Student:** Everything in the collection and showcase plus documentation for assessment.

4. **Teacher Resource:** Private use—shared with parent.

   Portfolio Content Possibilities: The portfolio is not limited in scope or size, and numerous pieces of student work can be included. The portfolio can easily be the most comprehensive form of assessment and documentation of student growth. Student ownership of the portfolio and responsibility for organization should be encouraged.

Portfolio Content Possibilities				
projects	reports	poems	thoughts	audio tapes
cassettes	teacher/parent notes	writing showing growth	evidence of effort	attitude surveys
ads	advice columns	tests	labs	class notes
dated material	newspaper clippings	research notes	questions	outlines
surveys	units of reading	songs	finished products	video tapes
responses	first/last drafts	peer responses	writing that illustrates self evaluation	journals
quizzes	observations	wishes	comments	group work
letters	pictures (drawn and photos)	resources	interviews	concept maps

III. Possible Methods to Implement Alternative Assessments

Only two major types of alternative assessments have been described to represent an attempt to illustrate the contemporary stream of thinking about alternative assessment, Many assessment methods are available to help implement alternative assessments into teaching practice, and a sampling of these are set out in this section.

1. Observations

Raizen and Kaser (1989) have noted that:

> *"Observations help the teacher determine which student appears to be having difficulty, who has problems using the hand lens and the scales, who contributes interesting ideas, who hangs back, ..."*

Observation is a way to assess student abilities in science. Teachers are always observing students in their classes, but **very few teachers consider the act of observing as a form of assessment**. If assessment focuses on the totality of student performance in the classroom, an excellent way to evaluate student work in the lab or in the class is for the teacher to keep observational records. Direct observation and the recording of those observations will give a better account of what students are capable of doing as they work in typical situations.

Observation can also inform the teacher about which students know how to use the library, how to take notes, where to get the information for those notes, how to use the computer, microfiche, and the internet. If assessment is concerned with evaluating the "whole" student, observation can play a key role in that evaluation, and observations can provide teachers with continued guidance in helping students have maximal success in the classroom.

Observational assessment suggestions can provide a more comprehensive picture of student involvement in the classroom. A checklist can be useful for focus and for documentation of observed behaviors. Some indicators that could be included in the list of observations would indicate that a student:

- has curiosity, positive attitude toward learning, investigative spirit;
- strives for independent learning;
- asks appropriate questions;
- suggests productive alternatives and/or extensions;
- shows personal responsibility;
- exemplifies responsible use of time;
- demonstrates responsible use of laboratory equipment and facilities;
- is prepared for class activities;
- accepts group responsibility;
- contributes to group understanding;
- is receptive to ideas/opinions of others;
- helps keep the group on task.

2. Concept Mapping with Clinical Interview

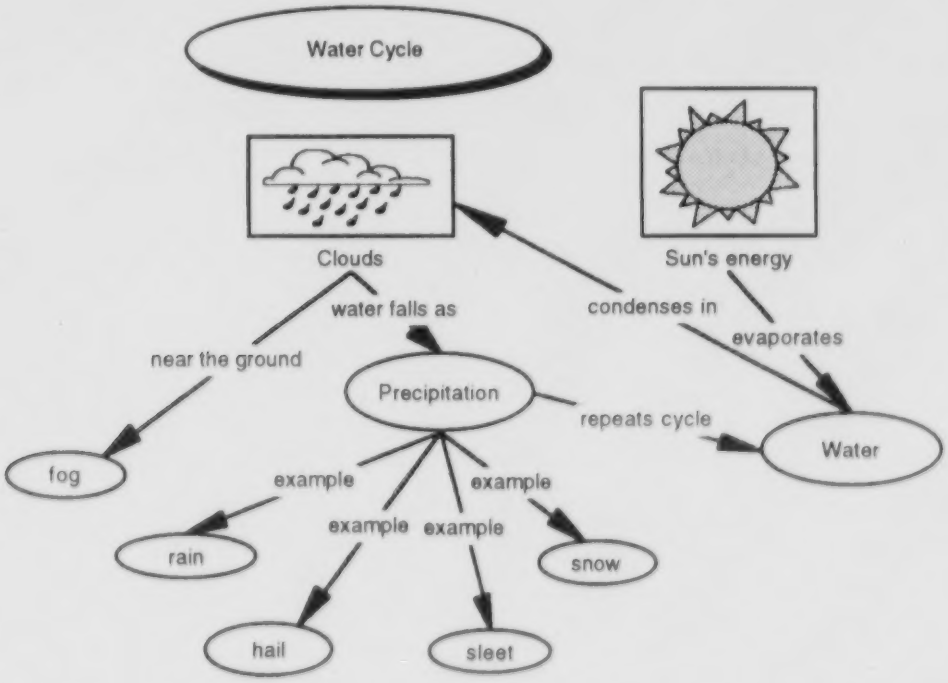
a. Concept Mapping

Essay questions can provide valuable information about what students know and understand. While essays provide a great deal of information about the student, they may not be applicable in all situations because of the time required to read them. Concept maps, or "webs" provide a graphic look at student understanding. If most of the words in an essay were removed, the backbone for a concept map should emerge. An example based on water cycle follows.

Essay Beginnings...

Water on the surface of the earth is evaporated by the energy of the sun. Clouds form from this water, and this water can eventually fall back to earth as rain or any number of other forms of precipitation.

A concept map for this sentence could look like this:



b. Clinical Interviewing

The clinical interview, developed by Piaget, has been adopted by researchers concerned with the prior knowledge, alternative frameworks, or misconceptions held by students and is considered a tool to be used following student concept mapping (Novak & Gowin, 1984). The interview allows the teacher to orally interact with the student and to probe for further clarification of their concept maps. This can facilitate assessing what the student may be unable to communicate via the written words.

If teachers follow some simple guidelines, the interview can be a powerful tool in establishing student's prior conceptual frameworks and evaluating student learning at any point in instruction.

1. Plan the interview. If possible use concrete objects, situations, or pictures.

2. Select appropriate questions to ask the student. Ask questions designed only to find out what students know about the issue or the concepts involved. Avoid "yes/no" questions. Do not ask questions designed to aid student understanding of the issue. Let them talk without fear of right or wrong. Get them to describe, predict, or explain.

3. Sequence the questions from the easier to more difficult ones. It is important to establish student confidence so the student does not become nervous and uncomfortable during the interview. The real goal is to seek explanations.

4. Students should be given adequate time to answer the questions. If the student fails to respond to the initial question or says he/she does not understand the question, the question should be restructured so as to give the student a chance to be successful.

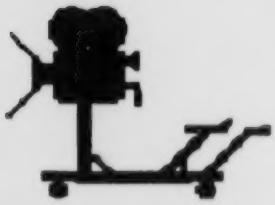
5. Whether it is the first time for teacher or student, or the tenth, it is important to convey a relaxed presence. Interviewers should project the image that they are human and/or that they do not know all the answers.

6. In any sequential interview, it is important to refer to prior interviews or relevant intervening instruction, ant the student's ideas should be used. This gives the student a frame of reference from which to respond, makes the conversation "roll", and gives evidence of teacher acceptance.

7. The language of the student should be used when rephrasing questions or probing further. To insist on the "right" word or pronunciation can be confusing and inhibit fuller expression of concepts and propositions. Also, students will sometimes use the wrong label (word) for the right concepts. (For example, students will often say that the earth is shaped like a circle, rather than a sphere). When this occurs, an explanation can be asked for and the correct concept label supplied by the student.

8. Finally, interviews should conclude on a positive note. Cooperation, manners, and answers to questions of the student can be noted; any questions the student might have can be answered. In any case, the interview should end with feelings that will make future interviews an experience to be welcomed and anticipated (Novak & Gowin, 1984).

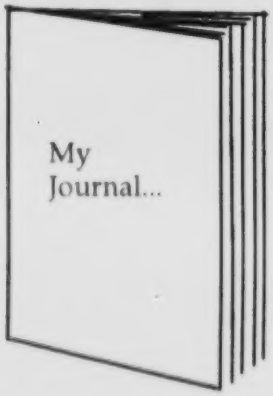
3. Video Taping



Video taping can add a technological form of assessment information. Audio taping can also be used with students to help them view their own abilities and knowledge in any particular area. Simply setting up the camera and letting it run while class is going on can provide valuable information for instructional improvement. Teachers can view the tape at a later time for self-evaluation, or the tape could be viewed with a colleague and peer evaluation used.

4. Journaling

The journal is a diary-like series of writings and/or drawings. The student should have a separate book or folder for the journal. Entries can be responses to an instructor's questions or statements, feelings about an activity, or "what did I learn today?" The focus on writing is a strength feature of journals. Students gain practice in their writing skills while communicating their ideas on paper.



The list of positive aspects of student journals is lengthy. For example, connection of knowledge between subject areas can occur when journals are used. Teachers are better able to respond to individual questions as the journals are read at various times, and a teacher-student dialogue can be established. Long term improvements within the course and teaching methodology can result in response to insights gained from students.

5. Brainstorming

Brainstorming can be used as a pre-assessment strategy to determine what students know about a question or issue they will be investigating. Students could first be asked individually to write down all they know about the topic. After this preliminary

session, a class or group brainstorming session could occur. The teacher could at a later point use the papers and notes from the initial session to document and assess growth in that area. When brainstorming serves as an introductory instructional activity, questions are formulated to discover what students know in general which can serve to provide an assessment of what they do not know in the topic area.

To be certain that every student has a pre-unit assessment for, ask each of the students in the class to take a moment to record his or her thoughts either in a science notebook or on a separate sheet of paper before the entire class conversation begins. The exercise of writing before they discuss can also lead to a more engaged class discussion, since the students will have focused on the topic and thought about what they want to say.

At the end of each lesson unit, teachers again ask the students to individually record what they know prior to the group discussion. If the information collected from the different periods of brainstorming is carefully documented and analyzed, it is likely that teachers and students would note growth in understanding from the learning experiences.

6. Open-Ended Questioning

Open-ended questions invite multiple solutions and multiple ways to arrive at solutions. Open-ended problems assist students in the development of problem-solving skills, as well as promoting creative and divergent thinking. They move students away from guessing what the teacher wants and also away from the prevalent notion that there is one right answer to all problems. In fact, this open-ended assessment approach becomes less of a guessing game and more of a preparation for the real world where multiple solutions are not only possible but often necessary. In the California Scope, Sequence, and Coordination Project, teachers were encouraged to design this type of assessment which fit into their assessment framework.

Typically, the open-ended questions can be developed by using the following process:

1. Identify "BIG IDEA(S)" and subconcepts to be assessed;

2. Determine the cognitive skills to be assessed;

3. Design a scenario or storyline that can be used to elaborate student thinkings;

4. As a teacher write your own sample answers;

5. Pilot the assessment questions with a few students;

6. Compare the student responses with your expected outcomes. Check to see if they match and if you are eliciting the responses that you expect. Rewrite and revise based on what you find;

7. Draft a scoring rubric and score student papers. You may want to introduce your students to rubrics and let them assist with the design and scoring process. When possible share the rubric with students prior to the assessment. It is very often a good idea to share exemplary responses with students prior to the assessment so that students are cognizant of expectations.

7. Self Report Knowledge Inventory

A self-evaluation instrument, the Self Report Knowledge Inventory (SRKI), asks students assess their knowledge of concepts and skills on a five-point scale. The SRKI works well for assessing students' prior knowledge.

The instrument includes the concepts the teacher expects the class to focus on during instruction. Following each concept, a list of five choices that students mark indicates their level of understanding of the concept. The SRKI could be administered as a pretest and also during the period of instruction to allow students to monitor their progress. An example of the SRKI used at the beginning of a lesson on maintaining glucose concentration in the blood is provided.

Concepts/Words:

___carbohydrates	_____concentration
___starch	_____glucose
___digestion	_____function of glucose in the cells.

For each of these concepts/words indicate how familiar you are with that concept or word. Write a number in each of the blanks from the choices below.

1) I have never heard of it.
2) I have heard of it but do not understand it.
3) I think I partially understand it.
4) I know and understand it.
5) I know and understand it, and I could explain it to a friend.

Teachers can utilize the responses provided by the students to direct or guide instruction so that students can reach the fourth or fifth level. This tool is user friendly and is non-threatening to the students, since they can mark any of the choices and not worry about being right or wrong. The ability to evaluate one's own knowledge is itself an important goal of education. The time needed to design, administer, and score the SRKI is minimal, the results have been found to be valid and reliable (Tamir & Amir, 1981).

B. NATIONAL SCIENCE EDUCATION ASSESSMENT STANDARDS

The assessment standards provide criteria to judge the quality of the assessment practices used by teachers, state and federal agencies to measure student achievement and the opportunity provided for students to learn science (NRC, 1996).

Standard A: Coordination with intended purposes

Assessments are consistent with the decisions they are intended to inform.

- Assessment are deliberately designed.
- Assessments have explicitly stated purposes.
- The relationship between the data and the decisions should be clear.

- Assessment procedures need to be internally consistent.

Standard B: Measuring student achievement and opportunity to learn

Achievement and opportunity to learn science must both be assessed.

- Achievement data focus on the science content that is most important for students to learn.
- Opportunity-to-learn data focus on the most powerful indicators of the students' opportunity to learn.
- Equal attention must be given to the assessment of opportunity to learn and to the assessment of student achievement.

Standard C: Matching technical quality of data with consequences

The technical quality of the data collected is well matched to the decisions made and actions taken on the basis of data interpretation.

- The feature that is claimed to be measured is actually measured.
- Assessment tasks are authentic.
- An individual student's performance is comparable on two or more tasks that purportedly measure the same aspect of student achievement.
- Students have adequate opportunity to demonstrate their achievements,
- Assessment tasks and methods of task presentation provide data that are sufficiently stable to lead to the same decisions if used at different times.

Standard D: Avoiding bias

Assessment practices must be fair.

- Assessment tasks should be reviewed for the presence of stereotypes, for assumptions that reflect the perspectives or experiences of a particular group, for language that might be offensive to a particular group, and for other features that might distract students from the intended task.
- Large-scale assessments must use statistical techniques to identify potential bias that could contribute to differential performance.
- Assessment tasks must be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities, or limited English proficiency.
- Assessment tasks must be set in a variety of contexts, be engaging students with varied interests and experiences, and tasks should not assume the perspective or experience of a particular gender, racial, or ethnic group.

Standard E: Making sound inferences

The inferences made from assessments about student achievement and opportunity to learn must be sound.

- When making inferences from assessment data about student achievement and opportunity to learn science, explicit reference needs to be made to the assumptions on which the inferences are based.

C. EMBEDDING ASSESSMENT STANDARDS IN TEACHING PRACTICE

No matter what statements are set forth in the National Science Education Standards, teachers hold the best position and most of the responsibilities for implementing those assessment guidelines in real teaching contexts. In this section, the tenets and some technical considerations of how to implement assessment guidelines into a classroom will be addressed. However, the ways described are by no means exhaustive, but rather, they represent an attempt to draw more attention to looking at potential applications.

I. Tenets for Context-Bound Assessment

1. A given assessment is one way, but not the only one, to provide evidence for meeting teaching goals. An assessment task is not the sole purpose for teaching nor the sole purpose of learning. Assessment should be considered a tool in the service of the learner rather than as a teacher effectiveness measure.

2. The integration of assessment tasks into real-world problem-solving contexts which call for many learning facets should be a goal of assessment. Multiple assessments are recommended, and an emphasis should be placed on monitoring students' performances throughout the learning process in addition to a culminating assessment.

3. Although it may not be explicit how the opportunity to learn can be assessed and how bias in teaching practices can be avoided, a responsible teacher still needs to be aware of and control as many factors as possible to reach a fair judgment when a given assessment is utilized. When looking at student outcome measures, questions that should be raised are those of when and where students have had the opportunity to experience and learn the information being assessed.

4. While assessment standards are most often set by individuals other than students, the teacher can at least invite all of the students to participate in the establishment of criteria for their assessments. Students should have an opportunity to contribute what they agree to learn and to learn how to assess their own learning. It is also a way to indicate that assessment and learning are actually one thing with two sides.

5. The other way to interpret that "student learning is an active process" is through cooperative learning, i.e., through group work rather than individual performance. Peer evaluation and group performance can be considered in determining a final grade.

6. In addition to a normative comparison, personal growth, especially for below average students, ability level must be taken into account. Assessment should be used as a tool in service to the learner.

II. Put Assessment into Teaching Practice

While planning instruction and assessments, it is helpful to have guidelines for moving ideas into practice. Iowa-SS&C teachers have used some of the following strategies to guide their planning.

Planning instruction and assessments

1. Identify "Big Idea(s)" and subconcepts that are pertinent to the school or district framework for science. Identify possible science-related issues that could address these concepts.

2. Identify the assessment strategies and approaches that have potential for alignment. Would it be possible to use a performance assessment to capture student performance and understanding of these big ideas or subconcepts? Do these big ideas align with three of the six domains of science (concepts, process skills, and applications)?

3. Decide upon more than one major assessment task that students will perform during the learning process, such as a project study, group discussion, a demonstration, and/or a presentation, and the possible weight of each task;

4. Consider possible ways to survey students' opportunity to learn not only concepts, process skills, and applications, but also consider the opportunities that address attitudes, creativity, and the nature of science.

At the beginning of the unit of study/module

1. Teacher expectations for assessment and the ways curriculum can unfold should be clearly conveyed and discussed with students. For example, teachers may discuss with students their goals and evidence of learning, "how" student performance will be assessed, "what" kinds of data or works will be collected, and "when" the reports will be likely to be due;

2. Student participation in the planning of the curriculum and set standards of assessments is essential to promote student monitoring their own learning. Only real-world problem-solving activities, rather than textbook or memorization oriented tasks are meaningful to ask for gaining student involvement.

During the learning process

1. Make certain the flow of curriculum is flexible enough to cope with the interaction in the classroom and retain the "how, what and when" design indicated initially;

2. Maintain a supportive learning atmosphere;

3. There are many assessment methods which teachers can use to document student learning and modify the curriculum accordingly. For example, teacher observation could be the used to monitor student engagement;

4. Students need time to internalize learning expectations especially if they have not experienced more student-centered and open-ended learning environments.

Final interpretation of student performance

1. Validity and reliability of the assessments used to interpret and make decisions about student performance should always be scrutinized.

2. As the teacher, be certain that claims made about student performance are based on both sound assessments and data interpretation.

3. Teachers should use the information collected from student evaluations about what students perceive they are learning and doing. This feedback from students can inform the teacher in facilitating a student-centered classroom. Ideally, if students are learning in ways that are best for them, student performance should improve.

D. UTILIZE THE WEB AS AN ASSESSMENT RESOURCE

The web has a wealth of information on assessment. The user must be a discerning practitioner in the selection of assessments or ideas to be used in the classroom, but many excellent sites exist. The ten regional educational laboratories are excellent beginning points.

(1) http://www.lab.brown.edu (2) http://www.temple.edu/department/lss

(3) http://www.ael.org (4) http://serve.org

(5) http://www.sedl.org (6) http://www.ncrel.org

(7) http://www.mcrel.org (8) http://www.nwrel.org

(9) http://www.wested.org (10) http://www.prel-ohaua-1.prel.hawaii.ed

With the current emphasis placed upon assessment, many states have developed websites which include samples and exemplars for assessments. The NSES website can be accessed at http://www.nap.edu/readingroom/books/nses/html/. For evaluation and assessment information the Educational Resources Information Center (ERIC) website is http://ericae.net/.

CHAPTER 5: EVALUATING TEACHING PRACTICE

Consider the Possibilities: Action Research, Video Tapes, Journals, Instruments to Evaluate Teaching Practice, Science as Inquiry

Teachers are in a central position to determine the direction and success of educational reform. Educational reform is linked to teaching practice and professional growth, and professional growth requires the commitment of teachers. The Iowa-SS&C Project recognized the role of teachers in the improvement of science education and encouraged teachers to work as teams to engage in practical inquiry of their own teaching practice. The purpose of such inquiry was to identify characteristics of effective practice that could enhance student learning and understanding.

Teachers, when they collect data to answer questions about effective teaching practices, function as researchers engaged in inquiry. In education, many people categorize this as "action research" which means teachers systematically investigate ways by which they can improve their teaching and student learning. The *action* component is taken by the teacher in striving to analyze various aspects of teaching and learning. The term *research* indicates that a research plan is structured and available for public critique in the form of professional publications or presentations. Engaging in classroom action research means that teachers develop study plans that involve collecting data about students' achievement, opportunities to learn (OTL), and teaching practices.

When teachers conduct action research, many research questions can be posed and numerous strategies for data collection are possible. The teacher should work to refine and focus the research question to be addressed. If questions are too global, the action research process can become an insurmountable task. A highly focused question and good research design to answer the question is an imperative for success. The bottom line- keep the action research manageable within the context of the daily classroom activities.

One method available to examine student learning in the classroom utilizes video taping, since the camera can become the "eyes" the teacher who needs to record student actions for later review and critique. Teachers may miss student performances because other classroom duties take priority. For example, a Science/Technology/Society (STS) classroom video-taping session showed the teacher helping students get supplies from the supply area and the front desk, while at the same time a small group of students already working on their project were actively engaged in a debate on the potential consequences of their group plan. The debate and subsequent alteration of their plan provided the teacher with a clear picture of group participation, the scientific process and performance by this group, and the creative procedures utilized by the students. This scenario would have been missed if the video camera had not been utilized. Audio recordings can be also used in similar fashion.

The advantages of employing a video camera to help a teacher identify certain characteristics of the classroom were discussed by a group of teachers who attended an inservice leadership conference held at the Science Education Center at The University of Iowa. Some advantages of video use identified by teachers included the opportunities to view and critique components in the following listing.

- Student group participation;
- Student attentiveness;
- Student self-paced work;
- Student-student interaction;

- Student performance of science processes (i.e., observation, classification, measuring, communication);
- Student creativity (i.e., project work, adaptation of new idea or process, generation of new hypotheses);
- Teacher interaction with students;
- Teacher involvement in student performances;
- Teacher questioning strategies;
- Teacher presentation/facilitation skills;
- Potential areas for assessment.

The video tape along with other classroom artifacts such as photographs of classroom activities, journals, learning logs, and/or audio tapes can become a part of a teaching portfolio. It is recommended that criteria be set to use for viewing videos. These criteria can be set out in the form of rubrics or checklists. A number of "classroom learning environment" questionnaires can also serve as tools to explore how students respond to teaching practices. The use of some type of written criteria to be used in the critique and review process helps to provide a focus and documentation of events which can serve as benchmarks to which future data can be compared. This type of action research can become a longitudinal study for the teacher.

Teacher journaling is another tool that can help teachers reflect on what or how content pedagogical strategies have been implemented in the classroom. Teacher journal writing encourages thinking and can even serve the important function of integrating course content, self-knowledge, and practical experiences with teaching and learning situations. Journal entries can also provide evidence for a longitudinal professional growth profile. For instance, bi-weekly journal entries could focus on: (1) personal beliefs and knowledge about teaching and learning, (2) how students respond to the instructional strategies used in class, (3) how information learned through literature, colleagues, and inservice workshops is applicable in the classroom, and (4) personal reflections and feelings about the teaching and learning process.

A teacher journal related to the teaching experiences of an STS/Constructivist teaching unit is included here as an example. A self review of the entries can also provide insight on how reflective a teacher is. Ask the personal questions: Is what I have written only a description of activities the occurred, or is what I have written really reflective?

Reflective Teaching Journal: An Example From Practice

Entry 1

Our class is doing a nutrition / heart unit for our 20 day module. We discussed a food guide pyramid (the 5 food groups), how many servings are needed, etc. They were given a copy of the pyramid to keep. We will be making a booklet of all our information throughout our unit. They seemed pretty excited about the topic. Hopefully it will stay that way!

Entry 2

I gave the class a chance to come up with any ideas about nutrition that they would like to do or learn about. I was kind of disappointed, because they didn't really come up with anything original or helpful. I have lots of ideas myself, so hopefully we'll do fine! They took a "pretest" - on general nutrition / heart questions. The results weren't too bad, but I will be looking for lots of improvement and for them to become more knowledgeable.

Entry 3

We went into more detail with the 5 food groups; the required servings, etc. They got into groups and chose their favorite pizza. Then, they came up with what food groups and servings were in/on it. We all shared the results with the class.

Entry 4

The students are going to record what they eat for 3 days, starting today. They filled out their own food pyramid to refer to also. I'm finding I don't have as much time to get everything done like I'd like to in these class periods.

Entry 5

We are keeping and comparing the students eating 3 day record to the pyramid. Nearly everyone found some room to improve on at least one of the days! We started discussing "physical fitness."

Entry 6

We discussed different types of physical activities and their favorites and how it's good to do these for fitness. They got into groups and had a list of various activities. They marked boxes as to whether that activity falls under warm-up, strength, endurance, flexibility, and cool down.

Entry 7

We had a little more discussion of physical fitness. They also wrote on a paper what activities they did with their families. Then what they might add to their activities with their families and what they could try.

Entry 8

We are including self-esteem with nutrition and fitness. I gave them a chance to be specific about their strengths and accomplishments. They filled out a poster on "What I Like About Me"; "What I'm Good At"; "Things That Make Me Proud". We shared a few things with the class.

Entry 9

The students made a wellness pyramid to be "tossed" like dice. They would toss it and select a challenging question to ask or answer to review for a quiz on Monday.

Entry 10

We didn't have school yesterday because of weather, so we had our quiz today on the food guide pyramid, etc. I'm anxious to grade it tonight to see how they did.
I just finished grading the quiz - I was very pleased with the results. Everyone improved on their score from the beginning pretest. I've got lots more I want to cover. I hope I have enough days to do it in!

Entry 11

I videotaped myself today during class. It went pretty well. I think the kids were more excited about it than I was! They divided up into groups of 5 and made two school lunch menus to be chosen during one week of school next month. They had to follow the requirement of having all 5 food groups in their menu. They were enjoying it!

Entry 12

They continued working on their menus. We got together and chose which ones to use and also discussed it with our cook. Feb. 7-11 we got to have these original menus.

Entry 13

We began talking about the heart - it's purpose, parts, etc. We watched a video on how the heart works and discussed it afterwards. They had a fun sheet about the heart and what we talked about after that. Also a tape on "Interviewing a Heart."

Entry 14

I videotaped a little bit today on the heart. We had some discussion and used posters, and did a sheet for their booklets. I found out I use my hands a lot and could give more waiting time for my questions I ask my students.

Entry 15

I videotaped myself for my final part on tape. We discussed more on the heart and did a demonstration, which they got to participate in. We showed how a valve in your heart works by squeezing a demonstrator. We then used a siphon and "blood" and showed how your heart pumps blood; how it can pump faster when exercising, etc.; how it always goes one way, etc. They had fun with it! I'm finding I have many more things to cover and not enough time! I know I will go over 20 days in this!!

Entry 16

We practiced taking our pulse - resting and exercising. Some were surprised at the difference. I'm working on getting a speaker to come in and talk to the class. That has been difficult for me to get a hold of someone - I'm still trying, though. The kids didn't know of anyone, so it was up to me! We studied for a quiz on the heart tomorrow. They know their information well!

Entry 17

We took our heart quiz. We also decided to put smoking into the heart/nutrition unit. We took a pretest to see what they knew. We also did a "tar" demonstration to see how it collects in their lungs. (Poured dark syrup into a measuring cup - they said when they predicted how much collected in a person's lungs in a year.)

Entry 18

We watched a "smoking" video. We did a Mystery Bag Activity. They had to guess what was in the bag by asking 2 students clue questions. They answered yes or no; until they guessed what was in the bag by gathering information and narrowing possibilities. Which is the same thing scientists and doctors have to do to figure out what causes heart disease/smoking and how it affects your heart, etc.

Entry 19

We took the smoking pretest again - they scored much, much better after all of our discussing and other activities. We related back to eating right/ nutrition and talked about snacks - what's good for you, etc. They divided up into groups and talked about healthy snacks.

Entry 20

The groups are coming up with 2 original snacks of their own. We will be making these into a recipe booklet and also trying some of them - sampling! (Yum!) They were expected to mark off which food groups the ingredients came from also. They enjoyed working on them.

Entry 21

We each had a partner today and were "Racing Raisins." (It dealt with carbon dioxide. The raisins were placed in soda pop. After sinking, they watched how many times they got to the surface. (They could do what they wanted to help it get to the surface, if they wanted to.) It was a challenge.

Entry 22

We were all Science "Fizz Whiz" people! We were in pairs and coming up with how soda is different from all other liquids - (has carbon dioxide.) We then did as an activity where they put different things in soda (sugar, salt. sand, cotton swab, etc.) and watched what happened. They wrote or recorded what happened after each one. We discussed it afterwards. The kids thought it was great!

Entry 23

We collected menus from various restaurants. We compared them, seeing if they had all the food groups somewhere, what kinds of foods available, etc. They got into groups and talked about this and then reported to the class on the different ones. They learned which nutritional restaurants to go to!.

Entry 24

Groups again! They decided which food group to use and are building a person using foods from that group. They will bring the ingredients needed in a few days. Continued menu reporting also.

Entry 25

Our speaker came today and talked about nutrition and the heart. She had bypass surgery and knew lots about nutrition. The kids were interested and asked lots of questions. I wanted a dietitian but couldn't find one. Next month a nurse will be coming, which should prove to be valuable also. She's also planning on taking blood pressures, etc. We'll look forward to that.

Entry 26

The foods were brought for our person they'll make. They constructed them today and had fun. We had 6 different ones. They only used either the fruit or vegetable group. I thought we might have more of a variety. They turned out well. We will show them to the preschool tomorrow. We worked on the skits also.

Entry 27

The preschool loved the "food persons". Gave them some good examples for snacks. We also worked on our skits. They will be presented in a couple of weeks. The menus they made up were eaten at lunch all week this week. The kids were famous!

Entry 28

We played some nutrition games using what we learned. We reviewed each other things for a mini-quiz.

Entry 29

We had a mini-quiz. They did wonderful. We also played a game as a review. They then "webbed" and put up everything they'd learned. It was wonderful compared to when we'd started. I'm wrapping up my journal - we have a few loose ends to cover, but will finish up eventually. It's been fun; lots of work involved, but it was worth it. I'm ready to start another unit of STS.

Video Taping

The use of video tapes to inform personal teaching perspectives aligns well with the construct of the teacher as a reflective practitioner. Video tapes of class lessons can provide feedback to inform teaching practice from self-evaluation of the video tapes. Peer review of video tapes also can be a very powerful tool for constructive feedback, and these tapes also provide an opportunity for others to see examples of exemplary teaching. The form that follows can be modified to conform to classroom needs. For example, if the teacher wished to focus on the kinds of questions being asked, s/he could provide descriptors and codes of question categories and then just enter the code and tally in the matrix.

Video Assessment of Classroom Interactions

© SS&C/Iowa-1993 (revisions-1998, Enger)

Teacher Name: _____

Context of Video Tape Events (Date)	Time Spent Dispensing Information	Time in Front of Classroom	Time with Individual Students/ Groups	Use of Student Questions	Kinds/Levels of Questions
Tape 1					
Tape 2					
Tape 3					
Tape 4					
Average					

Number of Students	Class Period Length
Type of Instruction	Grade Level

Comments/Reminders:

Viewing Classroom Videos:
Looking for Evidence of Effective Teaching Practice

1. Expectations for Student Learning

Were expectations for what students were to know and be able to do conveyed with clarity? What evidence supports the observations?

2. Questioning Strategies:

Were various levels of questioning used?
What levels of questions were asked?
Did the questions elicit student thinking at various cognitive levels?
Were students engaged in asking questions relevant to the class activities?
Was wait time practiced?
How did I respond to student answers?
What kind of feedback did I provide?
Did all students have the opportunity to respond to questions?

3. On Task Behavior:

Were the students on task? What evidence supports these observations?
Was the room arrangement conducive to on-task behavior? What evidence supports these observations observation?
If students were not on task, what changes could be made in this lesson in the future?

4. Use of and Modeling Instructional Strategies:

Were appropriate instructional strategies used during the lesson?
Were appropriate instructional strategies modeled during the lesson?
Were multiple learning styles addressed during the lesson?
Did students have the opportunity to discuss what was going on in the class?
Did students have the opportunity to write about what was going on in the class?

5. Student Assessment

Was assessment embedded in the lesson?
What kinds of assessments were used?
What kinds of feedback were provided for students?

Self-Review of Classroom Video

[(after the SATIC Coding System) Varrella, Kellerman & Penick: 1993]

Record the number of times the following are observed during two 10 minute periods for each of the sections: A, B, & C.

A. Initiatory/ Informational	(early 10 min.)		(late 10 min.)	
Talking: (discussion &/or lecture &/or directions)				
	Yes/No	Open-Ended	Yes/No	Open-Ended
Questions: (initiatory)				

"mental notes"

B. Responding	(early 10 min.)		(late 10 min.)	
	Yes/No	Open-Ended	Yes/No	Open-Ended
Teacher-Centered: (rejects or accepts student comments, confirms answer, repeats question or comment, clarifies or interprets, answers question directly)				
Student-Centered: (asks students to clarify and/or elaborate)				
Teacher Facilitated Extensions: (teacher discussion extending from student comment or question)				

"mental notes"

C. Wait Time

	(early 10 min.)		(late 10 min.)	
	Yes	No	Yes	No
Wait Time I (after the question) teacher <——> student				
Wait Time II (after the first student response) student <——> student				

"mental notes"

(Record the number of students on or off task at as many of the following intervals as possible during the observation.)

D. On/Off Task	10 min.		15 min.		20 min.		25 min.		30 min.		35 min.		40 min.		45 min.	
Students on task/off task																

"Improvement Targets"

Science Classroom Observation Rubric

ESTEEM (Expert Science Teacher Educational Evaluation Model)
(Judith A. Burry-Stock, 1993)

Category I: Facilitating the Learning Process

5 Teacher is a facilitator of the learning process. Responsibility for learning is on the student.

A. Students are responsible for their own learning experience. Teacher facilitates the learning process. (Teacher-student learning experience is a partnership.)

B. Students are actively engaged in initiating examples, asking questions, and suggesting and implementing activities throughout the lesson.

C. Students are actively engaged in experiences (physically and/or mentally.)

D. Novelty, newness, discrepancy, or curiosity are used consistently to motivate learning.

E. Teacher does not depend on the text to present the lesson. Teacher and students adapt or develop own content materials for their needs.

3 The teacher presents the material and identifies the issues and topics. Students are actively involved in the lesson.

A. Students are not always responsible for their own learning experience. Teacher directs the students more than facilitating the learning process. (Teacher-Student learning experience is more teacher-centered than student-centered.)

B. Students are partially engaged in initiating examples and asking questions at times during the lesson.

C. Students are moderately engaged in experiences.

D. Novelty, newness, discrepancy, or curiosity are used sometimes to motivate learning.

E. Teacher does depend somewhat on the text to present the lesson. Teacher and students make some modifications.

1 The teacher presents the issues and topics. Students are passively involved in the lesson.

A. Students are not responsible for their own learning experience. Teacher directs the learning process. (Teacher-student learning experience is completely teacher-centered, i.e., teacher lectures or demonstrates and never interacts with students.)

B. Students are seldom engaged in initiating examples and asking questions during the lesson.

C. Students are seldom engaged in experiences.

D. Novelty, newness, discrepancy, or curiosity are used occasionally or not at all to motivate learning.

E. Teacher does depend solely on the text to present the lesson. Teacher makes no modifications with students.

Category II: Content Specific Pedagogy

5 Teacher is constantly making the content of the lesson relevant to student understanding.

F. The lesson mainly focuses on activities that relate to student understanding of concepts. Student relevance is always a focus.

G. Students have an opportunity to experience the relationship of the concept to their everyday lives.

H. During the lesson the teacher appropriately varies methods to facilitate student conceptual understanding; i.e., discussion, questions, brainstorming, experiments, log reports, student presentations, lecture, demonstration, etc.

I. Teacher consistently moves students through different cognitive levels to reach higher order thinking skills.

J. Content and process skills are integrated.

K. Concepts are connected to the evidence.

3 Teacher sometimes makes the content of the lesson relevant to student understanding.

F. Most of the time the lesson focuses on activities that relate to student understanding of concepts. At times the teacher drifts away from student relevance, but brings the lesson to a focus quickly.

G. Students partially have an opportunity to experience the reality of the concept; for example, through the teacher occasionally relating issues to students' everyday life with the content.

H. During the lesson the teacher sometimes varies methods to demonstrate the content; i.e., discussion, questions, brainstorming, experiments, log reports, student presentations, lecture, demonstration, etc. Variations may at times be appropriate.

I. The teacher sometimes moves students through different cognitive levels to reach higher order student thinking skills.

J. Content and process skills are not integrated.

K. Concepts are partially connected to evidence.

1 Teacher does not make the content of the lesson relevant to student understanding.

F. Much of the time the lesson focuses on activities that do not relate to student understanding of concepts. When the lesson drifts away form student relevance, the teacher does not readily bring the lesson into focus.

G. Students do not have an opportunity to experience the reality of the concept.

H. During the lesson the teacher uses only one method to demonstrate the content; i.e., discussion, questions, brainstorming, experiments, log reports, student presentations, lecture, demonstration, etc.

I. The teacher does not move students through different cognitive levels to reach higher order thinking skills.

J. Content is taught without process.

K. Concepts are detailed with a lack of connection.

Category III: Contextual Knowledge (Fluid control)

5 Teacher demonstrates a high level of proficiency in utilizing contextual knowledge during the lesson.

L. Students are confronted with their misconceptions and are motivated to gather evidence to resolve them.

M. Teacher demonstrates good interpersonal relations with students.

N. Teacher has continuous awareness of his/her student content understanding and modifies the lesson when necessary.

3 Teacher demonstrates a moderate level of proficiency in utilizing contextual knowledge during the lesson.

L. Students are sometimes confronted with their misconceptions and are motivated to gather evidence to resolve them.

M. Teacher demonstrates good interpersonal relations with students most of the time.

N. Teacher has a general awareness of student understanding and occasionally modifies the lesson when necessary.

1 Teacher demonstrates little or no proficiency in utilizing contextual knowledge during the lesson.

L. Students leave classroom with misconceptions.

M. Teacher does not demonstrate good interpersonal relations with students.

N. Teacher has little or no awareness of student understanding and does not modify the lesson when it is appropriate.

Category IV: Content Knowledge

5 Teacher demonstrates excellent knowledge of subject matter.

O. Exemplars and metaphors (verbal, visual, and physical) are frequently used and are unique, accurate and relevant.

P. Lesson concepts, generalizations, and skills are applied interactively as a coherent organization of events.

Q. Content is in-depth and comprehensive.

R. Information is accurate.

3 Teacher demonstrates adequate knowledge of subject matter.

O. Exemplars and metaphors (verbal, visual, and physical) are used and are accurate and relevant most of the time.

P. Lesson concepts, generalizations, and skills are integrated coherently most of the time.

Q. Lesson has depth and is comprehensive much of the time.

R. Most content is accurate.

1 Teacher does not demonstrate adequate knowledge of subject matter.

O. Exemplars and metaphors are rarely used and/or are not accurate or relevant.

P. Content (concepts, generalizations and skills) lacks coherency throughout the lesson.

Q. Content is shallow and incomplete.

R. Information is often inaccurate.

Are You a Constructivist Teacher?

(Developed from the work of Brooks and Brooks, 1993)

Teacher _____ **School** _____

Date _____ **Class Period** _____

For statements 1-12, mark the letter that best indicates your perception of your teaching.

Use the following categories: a = never b = seldom c = sometimes d = often

1. I encourage and accept student autonomy and initiative.	a	b	c	d
2. I use raw data and primary sources, along with manipulative, interactive, and physical materials.	a	b	c	d
3. When framing tasks, I use cognitive terminology such as "classify," "predict," and "create."	a	b	c	d
4. I allow student responses to drive lessons, shift instructional strategies, and alter content.	a	b	c	d
5. I inquire about students' understanding of concepts before sharing my understandings of those concepts.	a	b	c	d
6. I encourage students to engage in dialogue, both with other students and with me.	a	b	c	d
7. I encourage student inquiry by asking thoughtful, open-ended questions and encourage students to ask questions of each other.	a	b	c	d
8. I seek elaboration of students' initial responses.	a	b	c	d
9. I engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion.	a	b	c	d
10. I allow wait time after posing questions.	a	b	c	d
11. I provide time for students to construct relationships and create metaphors.	a	b	c	d
12. I nurture students' natural curiosity through frequent use of the learning cycle model.	a	b	c	d

*Complete this self-perception survey at the beginning of the year, at mid-year, and at the end of the year. This can provide a self-check and target areas that the teacher may want to change. Providing examples or scenarios from practice to support perceptions could be a very strong evidential accompaniment to this self-perception survey.

Student Instruction and Motivation Survey

(Geoff Giddings, 1993)

Name _____ **Student Number (ID#)**_____

Teacher _____ **Course** _____

Part I: Demographic Information

Circle the letter on the right which best describes you.

1. Gender:	a = female	b = male			a	b			
2. Ethnicity:	a = Asian d = Caucasian Other (please write in) _____	b = Black e = Native American/Alaskan Native	c = Hispanic/Latin		a	b	c	d	e
3. Grade:	a = 6/7 d = 10	b = 8 e =11/12	c = 9		a	b	c	d	e

For statements 4-78: Circle the letter which best matches your viewpoint.

Use the following categories:

a= Strongly Agree **b= Agree** **c= Disagree** **d= Strongly Disagree**

Part II: Preferred Instructional Pattern Questionnaire

4	I prefer my teacher to tell me about science rather than to read a science book.	a	b	c	d
5	I like it when I have to explain the results of my own experiment.	a	b	c	d
6	By studying alone I learn more than by studying in a small group.	a	b	c	d
7	In science classes, I would rather listen to the teacher than do other activities.	a	b	c	d
8	I like to do experiments which help me to understand the science I have learned.	a	b	c	d
9	I like the teacher to explain rather than have to learn from books.	a	b	c	d
10	Taking exams helps me to know if I have understood what I have learned in class.	a	b	c	d

(a= Strongly Agree b= Agree c= Disagree d= Strongly Disagree)

Remember: The following statements refer to your science class.

11	I find it hard to listen to my teacher for a long period of time.	a	b	c	d
12	I understand science concepts better if I have to explain them in my own words.	a	b	c	d
13	I dislike working in small groups in science.	a	b	c	d
14	I like my science teacher to decide how we learn science.	a	b	c	d
15	I learn more from doing experiments than by listening to teacher's explanations.	a	b	c	d
16	I feel confused when I read several books about the same science idea.	a	b	c	d
17	I like my science teacher to correct my homework.	a	b	c	d
18	I prefer to listen to my teacher rather than learn from doing experiments.	a	b	c	d
19	I like to find out something without the teacher telling me how to do it.	a	b	c	d
20	One of the best ways for me to understand science is to discuss it in class.	a	b	c	d
21	I would learn more if I could choose which science topics I should study.	a	b	c	d
22	I find it hard to do science experiments without instructions given by the teacher.	a	b	c	d
23	When I am interested in a scientific idea, I like to read more about it.	a	b	c	d
24	I would rather be tested by my teacher than anyone else.	a	b	c	d
25	I find it hard to understand science without my teacher's explanations.	a	b	c	d
26	I would rather find out about a scientific idea than have it explained by the teacher.	a	b	c	d
27	When working in small groups my classmates share with me what they know.	a	b	c	d

(a= Strongly Agree b= Agree c= Disagree d= Strongly Disagree)

Remember: The following statements refer to your science class.

28	I dislike the teacher telling me what I have to do when doing an experiment.	a	b	c	d
29	The best science classes are those in which we do experiments.	a	b	c	d
30	Student note-taking is more useful for learning than reading textbooks.	a	b	c	d
31	My classmates know better than the teacher whether I understand science.	a	b	c	d
32	By taking notes, I make sure that I study what the teacher wants me to learn.	a	b	c	d
33	Solving problems is one of the best ways for me to understand science	a	b	c	d
34	I express my ideas more easily when working in a small group.	a	b	c	d
35	Teacher's answers to the questions asked in class by my classmates help me understand science.	a	b	c	d
36	I enjoy doing experiments.	a	b	c	d
37	I would rather use computers to learn science than to listen to the teacher.	a	b	c	d
38	Taking an exam is not the only way of finding out if I have understood science.	a	b	c	d

Part III: Student Motivation in Science Questionnaire

(a= Strongly Agree b= Agree c= Disagree d= Strongly Disagree)

Remember: The following statements refer to your science class

39	I like to get good marks (grades), even if I have to work hard.	a	b	c	d
40	In science classes if I do not understand something, I look it up in a book.	a	b	c	d
41	I get worried if I cannot solve a problem in science.	a	b	c	d

(a= Strongly Agree b= Agree c= Disagree d= Strongly Disagree)

Remember: The following statements refer to your science class.

42	I would rather have friends than to be at the top of the class.	a	b	c	d
43	I do not like other classmates to know if I get a bad mark (grade).	a	b	c	d
44	I like learning about the latest discoveries and inventions in science.	a	b	c	d
45	I do not mind working hard in science lessons as long as I learn something.	a	b	c	d
46	I care about what my classmates think of me.	a	b	c	d
47	I think it is fun to compete with others for the best marks (grades).	a	b	c	d
48	In the science lab, I like to mix different chemicals in order to see what happens.	a	b	c	d
49	I am ashamed to obtain low marks (grades) on an exam.	a	b	c	d
50	I like to choose my friends to work with me when doing experiments.	a	b	c	d
51	I like the teacher to tell the rest of the class when I get good marks (grades).	a	b	c	d
52	I like to find out about new ideas in science.	a	b	c	d
53	I like the teacher to praise my efforts in science.	a	b	c	d
54	Having good friends is one of the most important things at school.	a	b	c	d
55	I try to lead in class discussions	a	b	c	d
56	I am interested in many scientific ideas that are not taught at school.	a	b	c	d
57	I try to pay attention to what the teacher says so that I will not miss anything important.	a	b	c	d
58	I do not mind classmates copying problems or work done by me.	a	b	c	d
59	I like to get the best mark (grade) on tests,	a	b	c	d

(a= Strongly Agree b= Agree c= Disagree d= Strongly Disagree)

Remember: The following statements refer to your science class.

60	I like to find out more information than what the teacher tells me in class.	a	b	c	d
61	I like the teacher to give detailed explanations when teaching.	a	b	c	d
62	I do not mind lending my books and notes to classmates.	a	b	c	d
63	I like to be one of the first to finish my class work.	a	b	c	d
64	Many new science topics make me want to know more about them.	a	b	c	d
65	I like the teacher to correct my homework every day.	a	b	c	d
66	I like my classmates to help me in class.	a	b	c	d
67	I am more interested in the mark I get than in the mistakes I have made.	a	b	c	d
68	When solving scientific problems I am interested on finding out the answers.	a	b	c	d
69	I try hard to please my teacher with my work.	a	b	c	d
70	I like working with friends when working in small groups.	a	b	c	d
71	In class discussions I like to be able to present the best ideas.	a	b	c	d
72	I enjoy reading books about science.	a	b	c	d
73	I like to do my best when doing my science homework.	a	b	c	d
74	I like working in small groups.	a	b	c	d
75	I do not like to show others my answer if they do not know how to do it.	a	b	c	d
76	I like to learn about new ideas in science.	a	b	c	d
77	I like homework because I learn more.	a	b	c	d
78	When working in small groups, I do not care with whom I work.	a	b	c	d

What happens in my science classroom?
student form

(Taylor, Fraser, and White, 1994)

Questionnaire Purpose:
This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right or wrong answers. This is not a test, and your answers will not affect your grade. Your opinion is wanted. Your answers will enable us to improve future science classes.

Teacher _____ **Student Number** _____

School _____ **Date** _____

For each item or sentence, circle the letter at the right which best describes you or your views.

1.Gender: a = female b = male a b

2. Ethnicity: a = Asian b = Black c = Hispanic/Latin a b c d e
d = Caucasian e = Native American/Alaskan Native
Other (please write in) _____

3. Grade: a = 6/7 b = 8 c = 9 a b c d e
d = 10 e =11/12

Learning about the world	Almost Always	Often	Some-times	Seldom	Almost Never
In this class....					
4. I learn about the world outside of school.	a	b	c	d	e
5. My new learning starts with problems about the world outside of the school.	a	b	c	d	e
6. I learn how science can be a part of my out-of-school life.	a	b	c	d	e
In this class....					
7. I get a better understanding of the world outside of school.	a	b	c	d	e
8. I learn interesting things about the world outside of school.	a	b	c	d	e
9. What I learn has nothing to do with my out-of-school life.	a	b	c	d	e

Learning about science	Almost Always	Often	Some-times	Seldom	Almost Never
In this class....					
10. I learn that science cannot provide perfect answers to problems.	a	b	c	d	e
11. I learn that science has changed over time.	a	b	c	d	e
12. I learn that science is influenced by people's values and opinions.	a	b	c	d	e
In this class....					
13. I learn about the different sciences used by people in other cultures.	a	b	c	d	e
14. I learn that modern science is different from the science of long ago.	a	b	c	d	e
15. I learn that science is inventing theories.	a	b	c	d	e

Learning to speak out	Almost Always	Often	Some-times	Seldom	Almost Never
In this class....					
16. It's OK for me to ask the teacher "why do I have to learn this?"	a	b	c	d	e
17. It's OK for me to question the way I'm being taught.	a	b	c	d	e
18. It's OK for me to complain about activities that are confusing.	a	b	c	d	e
In this class....					
19. It's OK for me to complain about anything that prevents me from learning.	a	b	c	d	e
20. It's OK for me to express my opinion.	a	b	c	d	e
21. It's OK for me to speak up for my rights.	a	b	c	d	e

Learning to learn	Almost Always	Often	Some-times	Seldom	Almost Never
In this class....					
22. I help the teacher plan what I'm going to learn.	a	b	c	d	e
23. I help the teacher decide how well I am learning.	a	b	c	d	e
24. I help the teacher decide which activities are best for me.	a	b	c	d	e
In this class....					
25. I help the teacher decide how much time I spend on activities	a	b	c	d	e
26. I help the teacher decide which activities I do.	a	b	c	d	e
27. I help the teacher assess my learning.	a	b	c	d	e

Learning to communicate	Almost Always	Often	Some-times	Seldom	Almost Never
In this class....					
28. I get the chance to talk to other students.	a	b	c	d	e
29. I talk with other students about how to solve problems.	a	b	c	d	e
30. I explain my ideas to other students.	a	b	c	d	e
In this class....					
31. I ask other students to explain their ideas.	a	b	c	d	e
32. Other students ask me to explain my ideas.	a	b	c	d	e
33. Other students explain their ideas to me.	a	b	c	d	e

Science as Inquiry Surveys

As a teacher your responses to the Science as Inquiry Survey can provide documentation for your perceptions of your classroom practice. The student form of the survey provides the opportunity for your students to input their perceptions. Comparisons can be made and the data used to profile the science learning opportunities from both student and teacher perspectives.

Science As Inquiry: Teacher Perceptions of Science Class

(©1997 by Sandra K. Enger)

The questions on this survey relate to elements of teaching practice in your science class.

Section 1: Science Classroom:

Rating scale for 1-34:
5 = Very often
4 = Often
3 = Sometimes
2 = Seldom
1 = Never

In your science class, how often do you have your students do the following?

1. work in groups or teams
2. work in groups or teams when they do science activities
3. work individually
4. do activities and experiments in science class
5. work alone to do science activities and experiments
6. design their own activities and experiments
7. try activities or experiments that they design themselves
8. test a hypothesis or question in their activities or experiments
9. control variables when they do lab activities or experiments
10. ask questions and then investigate their own questions
11. make predictions about what will happen before they do activities or experiments
12. set up a data table when they do activities or experiments
13. make observations when they do activities or experiments
14. write down their observations from an experiment.
15. write about the experiments that they do in a notebook, log, or journal
16. write down their own information from a science experiment
17. graph numbers from their experiments
18. discuss the results from their experiments
19. set up their own experiments or activities

20. try experiments more than one time to check their results

21. read about the research work that scientists do

22. discuss the research work that scientists do

23. discuss science articles from newspapers or magazines

24. go to the school library or media center to find science information

25. watch and then discuss science videos

26. have visitors come to class to talk about science

27. go on field trips on-campus (school grounds) that relate to what they do in science class

28. go on field trips off-campus that relate to what they do in science class

29. I do experiments for the class.

30. If activities or experiments do not appear to work as predicted, we discuss reasons why.

Who decides what science lessons and activities are done in science class?

31. I decide what the science lessons are about.

32. The students in the class decide what the science lessons are about.

33. I decide what science activities and experiments we do.

34. The students in the class decide what science activities and experiments we do.

Section 2: Science Assignments:

Rating scale for 35-44:
5 = Very often, (3 to 5 times a week)
4 = Often, (1 or 2 times a week)
3 = Sometimes, (1 or 2 times a month)
2 = Seldom, (1 or 2 times a year)
1 = Never (We do not do this in science class.)

35. How often do you give science assignments?

36. Do students work in groups to complete some assignments?

What kinds of assignments do you use in your science class?

37. Students answer questions at the end of a section or chapter in the science textbook.

38. Students write definitions of science words.

39. Students do science worksheets.

40. Students do concept maps, mind maps, or webs.

41. Students do assignments that require presentations.

42. Students do assignments that require the use of a variety of resources.

43. Students do assignments that require projects.

44. Students do assignments that require them to involve people from the community.

Section 3: Tests/Assessments:

Rating scale for 45-58.
4 = Frequently (for most tests/assessments)
3 = Sometimes (for some tests/assessments)
2 = Seldom (for very few tests/assessments)
1 = Never (I do not use these in science class.)

How often do you have the following on tests or for assessments ?

45. true-false questions
46. multiple-choice questions
47. matching questions
48. fill-in-the blank questions
49. short-answer questions
50. essay questions
51. short-term products or projects (take about 1 week to do)
52. longer-term products or projects (take more than 1 week to do)
53. written reports about science
54. maintain a science portfolio of their work
55. make presentations about their work
56. do concept maps, mind maps, or webs

Do you involve students in the following?

57. use student input for design of a scoring guide (rubric) for their work
58. use student input for decisions on how some science work is graded

Section 4: Equipment/Materials:

Rating scale for 59-69:
5 = Very often
4 = Often
3 = Sometimes
2 = Seldom
1 = Never

Do students use any of the following equipment or materials in science class?

59. balances or scales
60. thermometers
61. microscopes
62. magnifying lenses

63. meters sticks or rulers
64. timers or stopwatch
65. computers for word processing (typing)
66. computers with probes or science software
67. live animals or plants
68. preserved animals or plants
69. graduated cylinders or other containers to measure liquids

Science As Inquiry: Student Perceptions of Science Class

(©1997 by Sandra K. Enger)

The questions on this survey relate to things that you may do in your science class when you are learning about science.

Section 1: Science Classroom:

Rating scale for 1-34:
5 = Very often
4 = Often
3 = Sometimes
2 = Seldom
1 = Never

In your science class, how often do you do the following?

1. work in groups or teams
2. work in group or teams when you do science activities
3. work by yourself
4. do activities and experiments in science class
5. work by yourself when you do science activities and experiments
6. design your own activities and experiments
7. try activities or experiments that you design yourselves
8. test a hypothesis or question in your activities or experiments
9. control variables when you do lab activities or experiments
10. ask questions and then investigate your own questions
11. make predictions about what will happen before you do activities or experiments
12. set up a data table when you do activities or experiments
13. make observations when you do activities or experiments
14. write down your observations from an experiment.
15. write about the experiments that you do in a notebook, log, or journal
16. write down your own information from a science experiment
17. graph numbers from your experiments
18. discuss the results from your experiments
19. set up your own experiments or activities
20. try experiments more than one time to check your results
21. read about the research work that scientists do
22. discuss the research work that scientists do
23. discuss science articles from newspapers or magazines
24. go to the school library or media center to find science information
25. watch and then discuss science videos

26. have visitors come to our class to talk about science

27. go on field trips on-campus (school grounds) that relate to what you do in science class

28. go on field trips off-campus that relate to what you do in science class

29. The teacher does experiments for the class.

30. If activities or experiments do not appear to work as predicted, we discuss reasons why.

Who decides what science lessons and activities are done in science class?

31. The teacher decides what the science lessons are about.

32. The students in the class decide what the science lessons are about.

33. The teacher decides what science activities and experiments we do.

34. The students in the class decide what science activities and experiments we do.

Section 2: Science Assignments:

Rating scale for 35-44:
5 = Very often, (3 to 5 times a week)
4 = Often, (1 or 2 times a week)
3 = Sometimes, (1 or 2 times a month)
2 = Seldom, (1 or 2 times a year)
1 = Never (We do not do this in science class.)

35. How often do you have science assignments?

36. Do you work in groups to complete some assignments?

What kinds of assignments do you have in your science class?

37. We answer questions at the end of a section or chapter in the science textbook.

38. We write definitions of science words.

39. We do science worksheets.

40. We do concept maps, mind maps, or webs.

41. We do assignments that require us to make presentations.

42. We do assignments that require us to use a variety of resources.

43. We do assignments that require us to complete projects.

44. We do assignments that require us to involve people from the community.

Section 3: Tests/Assessments:

Rating scale for 45-58.
4 = Frequently (for most tests/assessments)
3 = Sometimes (for some tests/assessments)
2 = Seldom (for very few tests/assessments)
1 = Never (We do not do this in science class.)

How often do you have the following on tests or for assessments ?

45. true-false questions
46. multiple-choice questions
47. matching questions
48. fill-in-the blank questions
49. short-answer questions
50. essay questions
51. short-term products or projects (take about 1 week t o do)
52. longer-term products or projects (take more than 1 week t o do)
53. write reports about science
54. keep a science portfolio of your work
55. do presentations about your work
56. do concept maps, mind maps, or webs

Do you do the following?

57. help the teacher design a scoring guide (rubric) for your work
58. decide on how some science work is graded

Section 4: Equipment/Materials:

Rating scale for 59-69:
5 = Very often
4 = Often
3 = Sometimes
2 = Seldom
1 = Never

Do you use any of the following equipment or materials in science class?

59. balances or scales
60. thermometers
61. microscopes
62. magnifying lenses
63. meters sticks or rulers
64. timers or stopwatch
65. computers for word processing (typing)

66. computers with probes or science software
67. live animals or plants
68. preserved animals or plants
69. graduated cylinders or other containers to measure liquids

C6

CHAPTER 6: RUBRICS

" A well-written rubric can help teachers score students' work more accurately and fairly; it can give students a better idea of what qualities their work should exhibit..."
[John O'Neil, 1994, ASCD Update, 36(6), pp. 1, 4, & 5]

Assessment should include the use of criteria designed to communicate goals and desired learner outcomes to the student. Rubrics/scoring guides can provide "umbrellas", overarching frameworks, that communicate criteria for activities, events, conceptual development, or goals for learners in the class. Rubrics/scoring guides can be designed for a wide variety of situations such as presentations, investigative projects, or performance tasks.

Criteria for student outcomes have been viewed many times as end-of-the-year goals are reached, usually one section, unit, or chapter at a time. Criteria should allow teachers to develop end-of-unit tests that indicate how each student is progressing towards the goal of understanding district objectives. Current understanding and reforms in science education depict learning as an active process in which the students learn individually, collectively, competitively, and collaboratively. Each of the aforementioned characteristics is present in the successful classroom; yet they are often not assessed because of district requirements for standardized testing, time constraints, or past training.

To assess the objectives represented by the type of active learning described above, student understanding should be assessed prior to instruction, during the instructional phase, and following the instructional sequence. Assessment should be viewed as an on-going component of the classroom. Many would argue that there is little time to do all of this assessment. The counter argument is that each student is an individual, and no two students could possibly know exactly the same material or have the same mental constructs for any subject. For students to develop understanding, time must be focused on these kinds of assessments, and the information collected used to inform future instruction. The results of these assessments should then be employed to develop the criteria each student will address prior to completing the instructional sequence. This is where a rubric or "expectation umbrella" can be used to focus thinking and learning for both the teacher and the student.

Chapter 6 includes examples of rubrics that have been developed and used by teachers. Teachers and their students have created these for their specific needs. Some rubrics are related to biology, some to concept maps, and others to physical science topics; the opportunities are limitless for adapting these to many learning situations. A selection of rubrics that provide examples of not very good rubrics is included at the end of the chapter.

A story from an Iowa teacher provides a look at her thinking about rubrics.

Rubric Construction: A Teacher's Thoughts

Courtesy of Linda Calvin, Urbandale High School, Urbandale, IA

A scoring rubric or "grid" is an essential part of an assessment model. The model speaks to being "up front" with the students in terms of what is expected and at what level

or standard the work should be done. The rubric is based on expected outcomes. The instructor asks him/herself what s/he expects that the student be able to do after having completed the work assigned. These expectations become the "outcomes" which guide student products or performances. The expected outcomes become "strands" on the scoring rubric. Each of the strands indicates to the student the standards for exemplary work, flawed but acceptable work, and work that must be "revised". The teacher might ask, "What is one outcome I might expect from a student writing a scientific investigation essay?" One of the most obvious outcomes would be that the student make few scientific errors. As a result, the strand for that outcome might appear as follows:

3	2	1
No major errors in scientific investigation.; high level of accurate information	Some scientific errors that distract the reader from the major significance of the information; some information inaccurate or omitted	Enough scientific errors to render the essay ineffective for useful information; important information highly inaccurate or omitted

The rubric intends to communicate to the student that accuracy of the investigation is of prime importance. The teacher would continue to build the rubric based on the desired outcomes for this particular assignment. The rubric could include other strands such as insights the student was able to form based on completed research, quality of the research materials used, ability to reach a sustainable conclusion based on clear evidence. Each idea or "outcome" would create one strand on the rubric. The descriptions of the standards should be parallel across the score points. A strand on resource use for this rubric follows:

3	2	1
Indication of multiple use of resources...good use of research to support thesis	Research goes beyond basic text...indication of use of alternative viewpoints...some additional information would enhance support of writer's thesis	Little or no evidence of research beyond the basic textbook

It is important to include only one desired outcome in the descriptors for the standards in each strand. The difficulty otherwise becomes one of deciding how to award points if the student achieves one part of a multiple strand but not all parts. If the strand contains only one idea, then it is clearer as to whether or not the student achieved the standard. Setting out the rubric or scoring guide in advance provides a communication guide for both the instructor and the students.

The instructor should be certain that all outcomes to be assessed are addressed in the rubric, since it would be unfair to assess the student on criteria not communicated by the rubric. If one reason for initially giving the student the rubric is to demystify the way in which s/he will be assessed, it would be unfair to change the rubric without informing the students. If a rubric has been prepared that does not contain an outcome that is later thought to be desirable, then the rubric should be rewritten if the same assignment is to be given later. Rubric/scoring guide development tends to become an iterative process as descriptors are refined with repeated use of the rubric/scoring guide.

Rubrics may appear to be subjective, since words like "no major errors" rather than "fewer than ten errors" are used. Numbers as indicators of standards negate much of the purpose of the rubric. If a rubric has standards which indicate exemplary work as having six causes of the Civil War, the student is expected to equate quantity with quality. S/he may have six causes, but are they meaningful causes? Are there more than six important causes? Is the student more interested in finding six causes than concentrating on the importance of causes? It is better to allow the student to decide for

him or herself how many important causes can be successfully supported as relevant. This allows the student to place more emphasis on quality of response rather than quantity.

Rubrics further serve the purpose of making papers easier and quicker to evaluate. Students are clearer as to what the teacher requires, which in turn leads them to write better papers. Teachers are also clearer about expectations. Therefore, reading the paper with the clear intent of evaluating what has already been established as standards enables the paper to be read more quickly with more focus on requirements. No longer does the teacher read papers to discover standards, but the standards for performance have been established at the outset.

In summary, a rubric can serve the student in the following ways:

- "Demystifies" expectations of the student by the teacher;
- Sets criteria and standards for performance;
- Allows the student to explain what s/he knows about a subject, rather than determine the right answer as identified by the teacher;
- Gives the student a clearer picture of how to organize a paper;
- Makes it easier for the teacher to objectively evaluate student materials that are somewhat subjective in nature.

Designing Rubrics/Scoring Guides

Before even beginning the design of a rubric/scoring guide, consider the assessment design. **Purpose** is the key that should guide the development of any assessment. What is the purpose of the assessment? Does assessment align with the learning experiences? What are the intended student outcomes that can be expected from students as a result of their learning experiences? What are the measurable student outcomes that can realistically be expected? To in some way capture the student performance, the use of a rubric/scoring guide can be a mechanism to communicate assessment intentions and to provide feedback to the students about their performances. The assessment information is often combined in some way with other information for grading and reporting purposes.

Rubric design and development can be accomplished in multiple ways. A general framework may be set up, and then this general framework is customized for specific assessments. The reverse strategy can also be used with a specific rubric designed for each assessment, and this could then be generalized. The general template approach may work well, in that the overarching assessment framework is in place. Nitko (1996) and Marzano, Pickering, and McTighe (1993) are two good references, and with the current emphasis on assessment, many other sources are available in print or on the web.

A general rubric grid could be organized like the following example. Three categories may suffice to assess the performance, and 5, 3 and 1 are often used to head the columns. A set of exemplars for each category can be collected over time and used to communicate to students what attributes exemplify each performance level. It is strongly recommended that if student work falls in the "not acceptable" category that constructive feedback be provided and where feasible the student provided an opportunity to resubmit the work. Equally important is the feedback to those whose work meets the "best" level so that the attributes can be met in future work.

Sample Grid

4 (Best)	3 (Good)	2 (Fair-Needs Improvement)	1 (Not acceptable)
This block usually holds what the teacher and students consider to be the best possible work that could be done by a student or group.	Work that achieves this level of success is good but does not meet all the criteria set by the teacher and students	Criteria in this block are set so that the work completed clearly shows that it could be improved upon.	This area contains that kind of work, attitude, or achievement that is considered to be unacceptable by the teacher and students.

It is very important that students have some degree of input in these criteria in order that they have some degree of ownership in their assessment.

The development of possible criteria and the resulting rubric are presented here. This style of rubric was employed for the assessment of student work from a biology class that utilized STS ideas. Numerous concepts that will show the necessary link to applications of science may be expressed by students.

Rubric for Interdisciplinary/Specified Domain Assessment

© Mason City, IA

Iowa-Scope, Sequence & Coordination Project (Iowa-SS&C Project)

Curricular Domain/ Science Domain	5	4	3	2	1/0
Scientific Thought (creativity, concepts, world view)	Original and creative design. Understands scientific principles of *(insert topic or concepts here)* very well.	Attempted original design. Some creativity. Understands scientific principles.	Model built from kit or plan. No creativity. Understands scientific principles.	Model built from kit or plan. No creativity. Partially understands scientific principles.	Model built from kit or plan. Little creativity. Does not understand scientific principles.
Presentation (language arts, speech, conceptual understanding)	Clear and concise. Effective use of scientific terms. Complete understanding of topic. Able to extrapolate.	Well organized. Good use of science terms. Good understanding of topic.	Presentation acceptable. Adequate use of science terms. Acceptable understanding of topic.	Presentation lacks clarity and organization. Little use of scientific terms and vocabulary. Poor understanding of topic.	No presentation.
Exhibit (attitude, world view, use of technology, art)	Model completed to specifications. Excellent workmanship. Materials are used in exemplary fashion. Information is self-explanatory.	Model completed to specifications. Good workmanship. Effective use of materials. Information is clear and logical.	Model completed. Adequate workmanship. Materials used appropriately. Acceptable information.	Model partially completed. Some problems with workmanship. Materials could be used more effectively. Some information is lacking.	Model not completed. Poor workmanship. Poor use of materials.

Biology: First Semester Final Assessment

(Gene Balk, Corey Lunn, Ty Huebsch, Mason City High School, Mason City, IA)

Task:

The U.S. Surgeon General has selected you and your colleagues to serve on a task force committee responsible for studying the environmental impact on health. To assist your task force, the Surgeon General has provided you with the following guidelines to ensure your group's success:

- Decide what environmental issue will have the most impact on human life;
- Research the issue your group has chosen;
- Apply the issue in detail to each body system studied;
- Develop a means to educate others about your findings;
- Critically evaluate and then summarize how your life will be different if this issue is not solved;
- Prepare proposals to the U.S. Surgeon General as to what possible modifications could be made to resolve this issue.

The rubric following can be modified for use in any module:

Criteria	10 (Determine your own exemplary standards)	9	8	7
References (depth of research)		Bibliography page with five different types of references	Bibliography page with four different types of references	Bibliography page with three different types of references
Application of system knowledge to environment		Two effects discussed per system. Three additional effects identified and discussed	Two effects discussed per system. Two additional effects identified and discussed	Two effects discussed per system. One additional effect identified and discussed
Accurate scientific support		Extensive support data included	Adequate support data included	Minimal support data included
* Reproduction				
* Respiration				
* Circulation				
* Digestion				
Educational means		Means extensively educates how systems are affected	Means adequately educates how systems are affected	Means minimally educates how systems are affected
		Creativity used to enhance means of education	Creativity attempted to enhance means of education	No obvious Creativity used
Summarization of life changes		Two examples of life changes summarized per system. Three additional examples included	Two examples of life changes summarized per system. Two additional examples included	Two examples of life changes summarized per system. One additional example included
Proposed modifications		One modification proposed per system. Two additional modifications included. Extensive description of resolution	One modification proposed per system. One additional modification included. Adequate description of resolution	One modification proposed per system. No additional modifications included. Minimal description of resolution
				Total Points = _____ (100-points possible)

The following rubrics are a sampling of those that have been successfully developed and employed by teachers participating in both the Iowa-SS&C Project and the Chautauqua Program. Any of the specific rubrics that match the needs in a specific classroom may be used intact; any formats that seem appropriate but do not meet specific goals or criteria can be used to construct a more appropriate rubric with the templates provided in this section.

Rubric for use in the Application Domain
A Proposal for Social Action

© Mason City, IA

Iowa-Scope, Sequence & Coordination Project (Iowa-SS&C Project)

Distinguished	Proficient	Intermediate
Proposal has realistic and practical applications.	Proposal has merit, but not realistic and practical.	Proposal not yet realistic.
Proposal supported by data (case studies, example, stats., etc.). Misconceptions cleared up	Proposal weakened due to lack of supporting data and/or a few misconceptions evident.	Proposal not supported by data.
Resources accurately documented in given format.	Resources documented—format not followed.	Resources not yet accurately documented.
Displays an understanding of the ethical question and comes up with a believable presentation of both sides.	Both sides of the proposal are presented.	Both sides of the proposal not yet evident.
Presents a variety of choices for possible ideas/solutions.	Possible ideas/solutions not fully explained.	Has not yet presented other possible solutions.
Explains the economic impact of the proposal.	Presents the economic impact of the proposal.	Economic impact not yet presented.
Explains how this proposal may affect future generations.	Presents how this proposal may affect future generations.	Has not yet presented how proposal affects future generations.

Realistic = persuasive/well grounded and documented
Practical = acceptable by society/potential for implementation

Rubric for Use in a Scientific Investigation

(L. Kellerman)

Distinguished	Experienced	Average	Novice
Student can apply all skills necessary to investigate a self-selected issue/problem.	Student can employ appropriate skills needed to investigate a self-selected issue/problem.	Student can employ some investigative skills to a problem identified by a significant other.	Student has difficulty identifying skills necessary to study a problem provided.
Student can recognize the phenomenon being searched for and develop explanation for it.	Student can identify the phenomenon being searched for and understands its nature.	Student has trouble identifying phenomenon being searched for and cannot explain the findings.	Student cannot identify phenomenon being searched for and is unable to explain why there is difficulty.
Student can report findings to fellow classmates and to other interested parties.	Student can report findings to fellow classmates and make findings available to others.	Student can develop a report to give to fellow classmates but has difficulty communicating to others.	Student cannot report to fellow students or others reasons for lack of identification of phenomenon.
Student can generalize findings to new and unique situations, thereby using the findings as a tool for investigation.	Student can generalize findings to other similar situations, making connections where appropriate.	Student can compare findings to other similar situations, but has difficulty making connections.	Student unable to recognize similar situations and similar phenomenological entities.

Students can be assisted in the journey toward the distinguished level.

Conservation Presentation Individual Assessment

(Linda Calvin, Urbandale High School, Urbandale, IA)

Individual Assessment

3	2	1
Explained and demonstrated very thoroughly their part in the presentation	Explained somewhat their part in the presentation but was not clearly understood	Said very little if anything what part they played in the presentation
Responsibility for their part of project was very obvious	Evidence of some time and thought put into part	Minimum of work was done—just enough to meet requirements
Shared ideas and feelings willingly in presentation	Some sharing occurred	Very little if any sharing
Background research very evident—four or more sources mentioned	Minimal background research evident—two or three sources	Very little evidence of research sources—zero to one source
Used colorful and clear visual in presentation	Visuals used were hard to understand	Used no media in presentation

TOTAL _____

Science Issue Project Rubric

(Linda Calvin, Urbandale High School, Urbandale, IA)

3	2	1
SOURCES • lists more than three • includes title, page, date • includes author	SOURCES • lists three sources • includes title, page, date • includes author	SOURCES • lists two sources • includes title, page, date
REPORT TITLE • relates to main topic • capitalized correctly • captures reader's interest	REPORT TITLE • relates to main topic • capitalized correctly	REPORT TITLE • related to main topic
CONTENT • many related topics • informative • well organized	CONTENT • relates to topic • informative	CONTENT • relates to topic
PARAGRAPHS • complete sentences • correct spelling • correct punctuation • correct capitalization • neat appearance	SENTENCES • complete sentences • correct spelling • correct punctuation • correct capitalization • neat appearance	SENTENCES • complete sentences
ILLUSTRATIONS • more than 1—titled • labeled correctly • neat appearance	ILLUSTRATIONS • title • labeled correctly • neat appearance	ILLUSTRATIONS • title • labels
ACTIVITIES • relate to issue question • informative • written conclusion • expand to new question	ACTIVITIES • relate to issue question • informative • written conclusion	ACTIVITIES • relate to issue question
COVER • title • name • date • illustration	COVER • title • name • date	COVER • title • name

A=21 POINTS **B=14 POINTS** **C=7 POINTS**

NO D or F will be awarded. All reports will be revised until an A, B, or C is earned.

Group Presentation Rubric
Conservation Presentation

Group Assessment

3	2	1
Presentation is clear, informative and teaches effectively	Presentation explained but lacks insight and enough preparation for teaching	Presentation not clearly explained
Good selection of items in presentation and very interesting, very organized	Selected items are appropriate but some presented in a boring manner	Selection of items presented are not interesting and show little effort
Issue clearly explained and listener gains insight	Issue explained well enough for listener to gain some insight	Issue not explained very clearly to give listener insight
Sharing and cooperation of group members is very obvious	Some sharing and cooperation was noted	Sharing and cooperation not obvious
Displays evidence of having used three or more different types of technology	Displayed evidence of using two types of technology	One or fewer types of technology were used
Closing includes information and supports conclusion	Closing states conclusion but does not use much information to support it	Closing is not stated
Wrote and sent a thank you to resource people		TOTAL _____

Electricity: Model Building

(A. Suchy, Melchor/Dallas School)

3	2	1	0
• Item of excellent design • Economical and appropriate use of materials • Complete circuit	• Item of good design • Some economical and appropriate use of materials • Complete circuit	• Item poorly designed • Wasteful or inappropriate use of materials • No complete circuit	• No item designed
• Picture drawn and completely labeled	• Picture drawn, but not labeled	• Picture drawn, but not labeled	• No picture drawn
• Materials list complete and practical	• Materials list complete but not practical	• Materials list incomplete	• No materials list
• Model built and works well • Model neatly done and attractive	• Model built but doesn't fully work • Model somewhat sloppy or unattractive	• Model built but doesn't work • Model sloppy and/or unattractive	• No model built

Rubric: Standards for Animals

BEST	ACCEPTABLE	UNACCEPTABLE
Tells other members about the book. Includes most significant details without repeating word for word. Listener would be able to retell with meaning.	Able to relate some significant details. May leave out some important ones which would help others understand the story better. Listener may not be able to get all important facts.	Tells some things about the story but facts are unrelated or may be insignificant. Listener would not be able to repeat the story.
Makes suggestions for animals to be included in new book which are logical in terms of a theme.	Makes suggestions for animals to be included which are logical to a theme. May leave out one or more or include one or more which is inappropriate to the theme.,	Unable to make appropriate suggestions for inclusions in a theme about animals. Choices are random and do not represent a theme.
Able to rewrite information in own words appropriate to the theme of the book.	Able to rewrite information in own words. May not always conform to the theme selected by the group.	Unable to rewrite copies from original work. Merely repeats what is already written.
Able to draw illustrations which reflect content of the theme.	Able to draw illustrations of animals. May not all reflect the theme.	Unable to complete illustrations or illustrations do not comfort to animals chosen for the theme.
Takes active part in decision making. Follows rules and exhibits courtesy toward others' ideas and actions.	Takes active part in decision making. May speak out of turn but not enough to disrupt the group.	Does not participate in decision making or uses time to disrupt the group.

Rubrics: Two examples That Have Student Input

Task:

You will work for a company that develops machines that can make everyday chores a little easier. You have just been asked to make a machine that uses two or more simple machine theories together to do one main function and make a one minute commercial demonstrating your invention.

Excellent	Good	Not Acceptable
Two or more simple machines used together in sequence.	One simple machine used or two simple machines used but not in sequence.	Simple machines not used.
Invention does function in desired way, realistically.	Invention works as shown but not realistic.	Invention does not perform desired function.
Simple machines used are described in a way to show how energy is saved.	Simple machines described inadequately as to energy savings.	No description of energy savings.

Criteria for Wildlife Project

Criteria	5 or 4	3 or 2	1
Appropriate season and climate	State which seasons your projects will be used, including why they are appropriate.	Seasons stated but appropriateness not stated.	Invalid seasons and climate.
Appropriate plants and animals for biome	Project is appropriate for the animals and plants in your area.	Project is appropriate for either animals or plants in your area.	Project is invalid for animals and plants in your area.
Description of biome food web	Describe how your project benefits your area, including a six to nine organism food web.	Description of benefits and four to five organism food web.	Description of benefits and less than four organism food web.
Description of environmental maintenance	Description of how your project will maintain the balance of nature.	Description only of your organism, not of surrounding environment.	Description invalid for organism or environment.
Presence of basic needs of organisms	Project adequately supports at least one basic need of organisms.	Project inadequately supports the basic needs.	Project does not support a basic need.

Rubric: Ice Fishing Shelter Construction

A third grade class has studied about the four seasons and how the season affects personal activities. During the winter, some students would like to go ice fishing. Richard has agreed to build a shelter for them, but the students must develop a plan for what they want built. Mrs. Morrison insists the shelter be as warm as possible because she dislikes winter. Please do not include anything that may melt the ice because Mrs. Morrison can't swim and doesn't want to learn how in ice cold water.

Draw and label a plan that Richard may follow to build this shelter. Be sure to include instructions about materials that are to be used and the dimensions he is to follow. Finally, include a paragraph explaining why your plan is the one our class should present to Richard. Give reasons that will convince us that you have developed the best plan.

3	2	1
Good selection of materials. They will do the job and provide insulation from the cold, reasonable comfort and durability.	Information about materials is provided but may not be the best materials for the job.	Does not provide information about materials used.
Dimensions are complete and reasonable. A good shelter should result.	Dimensions are given. May be unreasonable for the job or may be incomplete.	Doesn't give dimensions for the shelter.
Paragraph contains sufficient and good reasons why your plan is best. Should be accepted by the builder.	Paragraph explaining why plan is best is provided. May not be backed up with facts.	Paragraph describing why your plan is best is missing or superficial.
Project is clearly written and easy to understand. Attractive presentation causes builder to choose your design.	Project can be understood by lacks attractive presentation.	Project is messy and difficult to understand.
No errors in computation to interfere with successful completion of the shelter.	Enough errors in computation to cause finished product or turn out incorrectly.	Major errors have been made in computations.

Bottom Line: Not Every Rubric Is A Good or Useful Rubric

Portfolio Assessment Rubric:
A Good Example of a Not Very Useful Rubric

The following rubric is a "work in progress- not yet acceptable" category. Consider changing some of the wording. Does describe convey something different than explains? Are aesthetics important? The rubric conveys that aesthetics are, but what is beautiful to the teacher may not be so to the student. Other categories need work as well. What is cramped? The purpose of including this example is that it is a start, but it serves as a good example of a rubric that is not very useful for assessing a portfolio. If your classroom uses rubrics, revisit your goals and objectives, and structure your rubric around these.

CRITERIA	4	3	2	1
Explains what my successes are	Clear, complete, some creativity to clarify	Clear, complete	Complete, but unclear	Sketchy, Vague
Explains what is presently being done in my classes	Gives specifics and clearly identifies major parts of each unit	Gives specifics of all units or projects	Gives some specifics	Only vague ideas
Pleasant to look at	Beautiful	Nice	Average	Plain
Easy to read	Clear, correct fun to read	Clear and correct	Clear	Fairly clear
Organized	Well laid out with neatness	Neat no direction	Cramped	Cramped and messy

A Second Example of a Not Very Useful Rubric

The following rubric could be the template for a rubric to assess a laboratory performance related to the effects of gravity, friction, and mass on motion. From the rubric it appears that this may be some type of culminating assessment, since the effects of three variables are being considered. Some problematic words exist in this rubric. What is meant by accurately? What does relate/related mean? Nothing about the level of conceptual understanding is really conveyed. It sounds as if a textbook definition would also do the job, and that is probably not what the rubric developer had in mind. Rubrics take revision and refining. The Motions Concepts Rubric is in the "not quite there yet" stage.

Motion Concepts Rubric

5	4	3	2	1
Accurately computed speed		Attempted formula but miscalculated		Made measurements and attempted computations
Accurately explained the effect gravity has on motion		Partial description of gravity		Unable to relate gravity to motion
Accurately explained the effect friction has on motion, gave an example		Gave partial description of friction or gave an example of friction		Unable to relate friction to motion
Accurately explained the effect mass has on motion		Gave partial description of the effect mass has on motion		Unable to relate mass to motion
Accurately related three laws of motion		Accurately related two laws of motion		Accurately related one law of motion

A Third Example of a Not Very Useful Rubric
Essay on Ecology

Follow this rubric in preparing your essay.

Criteria	3	2	1
Cover	attractive/colorful	colorful	no color
Essay presents a lesson	clear and creatively presented	stated clearly	not clear
Supports the lesson	vivid details understand	little content	no content
Grammar	correctly presented	presented one to four errors	many errors
Use of capital letters	correctly presented	one to three errors	many errors
Illustrations	clear/colorful	clear	not complete

The message conveyed by this rubric seems to be that the essay is to focus on mechanics in writing. This seems counter to the title "Essay on Ecology" where from the title some criteria about understanding selected ecological concepts might have been expected. If the essay is going to be scored on writing mechanics, a separate score for these elements could be awarded, and a second rubric used to assess conceptual understanding. Also, no context, other than ecology, is provided with this rubric.

Evaluation of Science Frameworks

With the focus on classroom assessment, the alignment of the curriculum with district science learning outcomes becomes a task that often involves teachers and other district personnel. As districts affiliated with the Iowa-SS&C Project developed science frameworks, the alignment process was facilitated by the development of a framework rubric. The framework rubric, aligned with the NSES, could be used to focus the evaluation process when teachers began to examine and document the elements of the frameworks being established. The Iowa-SS&C Science Framework Rubric is set out on the pages that follow.

Iowa-SS&C Science Framework Rubric

(©1997 Iowa SS&C Staff)

This rubric is based upon the National Science Education Standards. Page numbers in parentheses refer to the 1996 National Science Education Standards (NSES). The rubric is intended for use in the assessment of district science framework alignment with the NSES.

1. Rationale

Elements	Not Evi-dent	2	3	4	Evi-dent
1.1 The rationale of the framework is succinctly written.					
1.2 The rationale explains how district goals align with the framework.					
1.3 The rationale explains how Science-Technology-Society is infused into the framework.					
1.4 The rationale explains how constructivism is incorporated into the framework.					
1.5 The rationale describes how the Iowa SS&C tenets fit into the framework.					
1.6 The rationale explains how National Science Education Standards fit into the framework.					
1.7 The rationale is written so that it is meaningful to a diverse audience.					

Comments:

2. National Goals and Outcomes: Evidence of Science Literacy

Elements	Not Evi-dent	2	3	4	Evi-dent
2.1 The framework reflects a richness of experience of knowing about and understanding the natural world (p. 13).					
2.2 The framework includes scientific processes and principles which can be used to make personal decisions (p. 13).					
2.3 The framework reflects an expectation that students will engage intelligently in public discourse and debate about matters of scientific and technological concern in the classroom (p. 13).					

Comments:

3.1 Content Standards Grades 5-12 — Unifying Themes

3.1 The broad unifying themes and processes are evident at all grade levels. The broad unifying themes and processes complement the analytic, more discipline-based perspectives presented in the other content standards (p. 115).	Not Evi-dent	2	3	4	Evi-dent
3.1a systems, order, and organization (p. 116).					
3.1b evidence, models, and explanation (p. 117).					
3.1c change, constancy, and measurement (p 117).					
3.1d evolution, and equilibrium (p. 119)					
3.1e form and function (p. 119).					

Comments

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3.2 Content Standards Grades 5-12 — Inquiry

3.2 The framework reflects an inquiry based approach to instruction at all grade levels. Inquiries are based on the types of questions explored which influence methodology, techniques, and core theories (p. 143).	Not Evi-dent	2	3	4	Evi-dent
3.2a The framework includes activities that develop student abilities necessary for conducting scientific inquiry such as: Refining and re-focusing broad and ill-defined questions; enhancing process skills; using appropriate tools; and thinking critically about evidence, anomalies, etc. (pp. 110, 145).					
3.2b The framework includes activities that develop student understanding about the process of scientific inquiry. Inquiries should lead not only to greater understandings, but also lead to new investigations (pp. 110, 148).					

Comments

4. Content Standards Grades 5-8 — Physical, Life, Earth & Space Science; Science and Technology; Science in Personal and Social Perspectives; and History and Nature of Science

4.1 The physical science standards for grades 5 - 8 are evidenced through student experiences based on the content, process, and concept goals outlined in the framework (pp. 106, 108).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
4.1a properties and changes in matter					
4.1b motions and forces					
4.1c transfer of energy					
4.2 The life science standards for grades 5 - 8 are evidenced through student experiences based on the content, process, and concept goals outlined in the framework (pp. 106, 108).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
4.2a structure and function in living systems					
4.2b reproduction and heredity					
4.2c regulation and behavior					
4.2d populations and ecosystems					
4.2e diversity and adaptations of organisms					
4.3 The Earth and space science standards for grades 5 - 8 are evidenced through student experiences based on the content, process, and concept goals outlined in the framework (pp. 106, 108).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
4.3a structure of the Earth systems					
4.3b Earth's history					
4.3c Earth in the solar system					
4.4 Science and technology student experiences for grades 5 - 8 explore the connections between the natural and designed world. These are based on the content, process, and concept goals outlined in the framework (pp. 106, 108, 161).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
4.4a abilities of technological design to meet human needs, solve problems, develop a product, etc.					
4.4b understanding the relationship between science and technology — distinctions, similarities, roles, and relationships.					

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4. Content Standards Grades 5-8 — Physical, Life, Earth & Space Science; Science and Technology; Science in Personal and Social Perspectives; and History and Nature of Science

4.5 Through the linkage of science in personal and social perspectives students, in grades 5 - 8, will have the opportunity to develop a means to understand and act on personal and societal issues. These are based on the content, process, and concept goals outlined in the framework (pp. 107,108, 166-170).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
4.5a personal and community health					
4.5b population growth					
4.5c natural resources					
4.5d environmental quality					
4.5e natural and human induced hazards					
4.5f science and technology in local, national, and global perspectives					
4.6 History and nature of science experiences are interwoven throughout the study of science for grades 5 - 8. These are based on the content, process, and concept goals outlined in the frameworks (pp. 107-108, 170-171). These are evidenced through experience in three broad areas.	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
4.6a science as a human endeavor — relying on insights, skill, creativity, scientific habits of mind tolerance of ambiguity, skepticism, and openness to new ideas					
4.6b nature of science — tentative nature of knowledge; experimental and observation evidence which contributes to major, established ideas of science; methods of scientific inquiry					
4.6c history of science — illuminating the history of innovation and thinking, practices in different cultures, and contributions of individual women and men					

Comments:

5. Content Standards Grades 9-12 — Physical, Life, Earth & Space Science; Science and Technology; Science in Personal and Social Perspectives; and History and Nature of Science

5.1 The physical science standards for grades 9 - 12 are evidenced through student experiences based on the content, process, and concept goals outlined in the framework (pp. 106, 108).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
5.1a structure of atoms					
5.1b structure and properties of matter					
5.1c chemical reactions					
5.1d motion and forces					
5.1e conservation of energy and increase in disorder					
5.1f interactions of energy and matter					
5.2 The life science standards for grades 9 - 12 are evidenced through student experiences based on the content, process, and concept goals outlined in the framework (pp. 106, 108).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
5.2a the cell					
5.2b molecular basis of heredity					
5.2c biological evolution					
5.2d interdependence of organisms					
5.2e regulation and behavior					
5.2f matter, energy, and organization in living systems					
5.2g behavior of organisms					

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5.3 The Earth and space science standards for grades 9 - 12 are evidenced through student experiences based on the content, process, concept goals outlined in the framework (pp. 106, 108).	**Not Evi-dent**	**2**	**3**	**4**	**Evi-dent**
5.3a energy in the Earth system					
5.3b geochemical cycles					
5.3c origin and evolution of the Earth system					
5.3d origin and evolution of the universe					

Comments:

5. Content Standards Grades 9-12 — Physical, Life, Earth & Space Science; Science and Technology; Science in Personal and Social Perspectives; and History and Nature of Science (cont.)

5.4 Science and technology student experiences for grades 9-12 explore the connections between the natural and designed world. These are based on the content, process, and concept goals outlined in the framework (pp. 107, 108, 161)	Not Evident	2	3	4	Evident
5.4a abilities of technological design to meet human needs, solve problems, develop a product, etc.					
5.4b understandings about science and technologies — distinctions, similarities, roles, and relationships.					
5.5 Through the linkage of science in personal and social perspectives students in grades 9-12, will have the opportunity to develop a means to understand and act on personal and societal issues. These are based on the content, process, and concept goals in the framework (pp. 107, 108).	Not Evident	2	3	4	Evident
5.5a personal and community health					
5.5b population growth					
5.5c natural resources					
5.5d environmental quality					
5.5e natural and human induced hazards					
5.5f science and technology in local, national, and global perspectives					

Comments:

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5. Content Standards Grades 9 - 12 — Physical, Life, Earth & Space Science; Science and Technology; Science in Personal and Social Perspectives; and History and Nature of Science (cont.)

	Not Evi-dent	2	3	4	Evi-dent
5.6 History and nature of science experiences are interwoven throughout the study of science for grades 9-12. These are based on the content, process, and concept goals outlined in the frameworks (pp. 107-108, 170-171). These are evidenced through experience in three broad areas.					
5.6a science as a human endeavor — ethical and moral traditions and dilemmas, influence of society and culture, the range and variety of scientific endeavor					
5.6b nature of scientific knowledge — the empirical standards which differentiate science from other ways of knowing; criteria for scientific explanations such as consistency, repeatability, and usefulness in making predictions					
5.6c historical perspectives — practices of different cultures; contributions of individuals their daily work; building on earlier knowledge contrasted with occasional and historic leaps of understanding; noteworthy advances such as germ theory and plate tectonics.					

Comments

6. Content Standards General. This section represents a general evaluation of the 5-12 content areas based on the review of the parts.

Elements	Not Evi-dent	2	3	4	Evi-dent
6.1 The concepts and processes found in the framework show connections among the scientific disciplines (p. 115).					
6.2 The concepts and processes found in the framework are at developmentally appropriate grades levels (p. 115).					
6.3 The continuum of complexity of the *sequence* (i.e., concrete to abstract) is evident in the framework (pp. 115-116).					
6.4 The framework includes integrative schemes, typified by the unifying concepts and processes (p. 116).					

Comments

BEST COPY AVAILABLE

7. Assessment Standards Grades 5-12

Elements	Not Evi-dent	2	3	4	Evi-dent
7.1 The framework explains the purpose of the assessments used (p. 78).					
7.2 Examples of assessments that assess achievement and are used for grading are included at all levels in the framework. (p. 79) .					
7.3 Assessments that probe for understanding, higher order reasoning and the application/utilization of knowledge are included at all levels in the framework (p. 82).					
7.4. Assessments at all levels are based on the content standards (p. 79).					
7.5. Assessment examples included in the framework reflect the nature of the classroom learning environment, i.e., they are based on and test in the context of study, similar to activities of scientists, and can be applied to everyday experiences (p. 83).					
7.6 Assessments at all levels are fair. They strive to be developmentally appropriate, use a familiar setting, are unbiased, students are given adequate time to demonstrate their achievement (pp. 83-4).					
7.7 Assessment examples included in the framework are issue based, set in a variety of contexts, and show personal relevance for students (p. 83).					
7.8 Assessment examples included in the framework include those used for the purposes of determining students initial understandings and abilities (p. 87).					
7.9 Assessment examples included in the framework are diverse, i.e., include opportunities for students to explain orally, in writing, or through illustration how a work sample provides evidence of understanding (p. 88).					
7.10 Assessment examples included in the framework provide students with opportunities to evaluate and reflect on their own scientific understanding and abilities (p. 88).					

Comments

Chapter 7: ASSESSMENT SAMPLES FOR ALL GRADE LEVELS

These instruments are only examples, and you are encouraged to infuse these ideas into your own experience and to construct more appropriate assessment tasks aligned with your instruction.

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Opportunities for Self Assessment/Evaluation

(Integrated Domain)

Some teachers ask their students to evaluate their own learning experiences. Two examples are provided. One example is related to small group work and the other to participation of individual students in small group activities.

GROUP EVALUATION

Group Activity: _____

Student Names: _____

1.	How did your group work together?	very well	well	not very well
2.	Overall, how would you rate your group's product? (poster, pamphlet, skit...)	very good	good	not very good

3. What do you think was the best part of your group's product?

_____

4. How do you think your group could have improved? _____

Individual Evaluation

(Integrated Domain)

Name _____

1.	How much did you contribute to the product?	more than others	same as others	less than others
2.	Did you offer ideas?	more than others	same as others	less than others
3.	Did you accept ideas from the group?	more than others	same as others	less than others

4. What would you like others to know about the work that you did on this product?

_____

Another example of reliance on students' self evaluation is the Media and Resource Use Inventory (below). This inventory is especially relevant to STS courses, where an independent search for information is recommended. The inventory also provides students and teachers with a "real world view" of those concepts they are studying in the classroom. It is one thing to learn the definition of acid rain, greenhouse effect, or biome from a textbook glossary or a teacher lecture; it is another to encounter those and similar terms in an article in Newsweek, Scientific American, a newspaper, or in an educational program on public television. Concepts have a real-world context when encountered in the popular media. This encourages learning of those concepts and provides a forum for the teacher to develop appropriate assessment instruments.

Media and Resource Use Inventory

(Integrated Domain)

Directions: Read each of the following questions. Check in the column that best describes **your** use of the information in the question. In the last column, estimate the number of times you used this information.

		Once in the past three months	More than once in the past three months	Never	Number of Times
1.	Have you used a phone to gather information for a project?				
2.	Have you obtained materials from the AEA for projects?				
3.	Have you obtained materials from other sources for projects?				
4.	Have you used a computer for class work?				
5.	Did you discuss science topics with adults?				
6.	Did you use the media (Internet, TV, newspaper, radio) to help with a project?				
7.	Did you take notes to help you remember?				
8.	Do you take notes when doing research?				
9.	Do you take notes voluntarily?				
10.	Have you contacted resource people to gather information?				
11.	Have you contacted a speaker to supplement your topic?				
12.	Have you introduced a resource person for a presentation?				
13.	Has interviewing been a part of your information gathering?				

Open-Ended Essays

(Integrated Domain)

Students respond to these questions by providing solutions to problems, explanations, and opinions. The responses can reveal students' ideas and conceptions much like an individual oral interview (Strauss & Stavy, 1983). A special variant of open-ended items requires students to provide definitions. The interpretation of responses in this case requires some caution since students can memorize definitions by rote (Ausubel, 1968). However, quite frequently, incorrect definitions reveal misconceptions (Barenholz & Tamir, 1991). In the following example, the statement is given, a question follows, and students are asked to explain. Responses 1-3 provide just a small sample of the potentially correct responses that could be provided by junior high students.

Example: **People are able to live normal lives eating only fruits and vegetables and no meat. How is this possible? Explain.** (Junior high level)
Explanation: No one fruit, vegetable, or meat contains all the necessary nutrients for healthy living. However, a vegetarian diet can be conceived which would provide all the essentials.

1. Draw a graph showing the number of calories in 10 grams each of bread, hamburger, and celery (Junior high level)?

2. What can we conclude from the graph drawn in Response 1?

   The student should draw a bar graph (not a line graph), provide an appropriate title, and record the units. The conclusion is that the caloric value of meat and bread is very similar whereas celery has a much lower caloric value.

3. What would you need to know in order to determine if school lunches are nutritious and healthy?

   We need to know the chemical composition of the lunches, the fats, carbohydrates and protein content, their caloric value, and the relative amount of the main elements nitrogen and phosphorus.

Student Laboratory Environment Inventory—(SLEI)

(Integrated Domain)

Laboratory teaching is one of the unique features of education in the sciences and an integral part of the Science/Technology/Society (STS) classroom. Although a great deal is known about hands-on learning, and many studies have corroborated that learning takes place best when one is "doing science", research has not been comprehensive when it comes to assessing the effects of laboratory instruction upon student learning and attitudes (Fraser, Giddings & McRobbie, 1992). Recently an instrument has been developed that is designed specifically for the science laboratory. The SLEI is intended for use in situations in which a separate laboratory class exists, so it may be most appropriate for upper secondary and higher education levels. It contains 35 items measuring five different dimensions, and has response alternatives of *Almost Never*, *Seldom*, *Sometimes*, *Often*, and *Very Often*. The instrument comes in two forms. The "Actual Form" asks students to note what **actually takes place** in the laboratory classroom, the "Preferred Form" asks students to respond to what they would **prefer to take place** in the laboratory class.

Teachers interested in administering this assessment instrument should contact the Chautauqua Program or the Scope, Sequence & Coordination Project at the University of Iowa for copies and further information at the address and phone listed in the Epilogue.

Each of the aforementioned assessment activities can be completed in the classroom within the realm of authentic assessment which is imbedded in the instruction. The students may be performing any one of these process skills during an instructional period and the teacher could, utilizing a predetermined observation checklist, observe the groups performing a particular class activity to determine a students' ability to perform that process. Following are some examples of items that could be used to assess some of the processes of science.

Student _____ Date _____

Activity _____ Process _____

(Strongly Agree = SA, Agree = A, No Opinion = N, Disagree = D, Strongly Disagree = SD)

1. This student was using appropriate process skills to determine the outcome of the activity.	SA	A	N	D	SD
2. This student performed the process skill within the context of the activity.	SA	A	N	D	SD
3. The process skill enhanced the learning taking place during this activity.	SA	A	N	D	SD
4. The other student performing this activity (agreed, no opinion, disagreed) with the performed process skill.	SA	A	N	D	SD
5. This student noted appropriately the performance of the expected process skill in the notebook entry.	SA	A	N	D	SD
6. This student needs additional experiences to practice this _____ skill.	Yes	No			

Methods for Assessing in the Application Domain

(Application Domain)

"Ask student to apply principles and/or skills in a completely new situation and encourage them to be unique" is a central theme to assess student learning in the application domain. Prior to assessing student's ability to apply concepts, teachers need to develop application questions. The following words and phrases should help. These are just examples and can be changed, and synonyms may be used to replace key words. Written properly and in the context of asking students to apply knowledge they have learned during the course of STS instruction, these key words/phrases help teachers determine student success in this domain.

How would you use	Separate	Show how	Identify	Similar	Graph
What is the use for	Arrange	Dissect	Explain	Different	Chart
What would result	Select	Unable	Conclude	Compare	Outline
If.....how	Cause for	Distinguish	Diagram	Classify	Apply
Illustrate how	Contrast	Construct	Reason for	Like	Demonstrate
How	Investigate	Plan	Choose the statements that apply		
Differentiate	Tell what would happen		Tell how much change there would be		
others...	_____	_____	_____	_____	_____

Following are some examples of application questions.

Which of the following methods is best for _____?

What steps should be followed in applying _____?

Which situation would require the use of _____?

Which principle would be best for solving _____?

What procedure is best for improving _____?

What procedure is best for constructing _____?

Which of the following is the best plan for _____?

What is the most probable effect of _____?

Application items deal with uses of information and/or skills often require original thinking. They:

- require knowledge of standard procedures;
- present a specific situation and require appropriate action, reasonable inference, or prediction;
- require solution of numerical or other mathematical problem;
- may present a statement or observation to be interpreted or evaluated;
- may assume unusual or impossible situation and require inferences.

When constructing assessment instruments or items employing the words and phrases presented here, bear in mind the students should model an **integrative** understanding of the learning that has taken place in the classroom. The students must

have the chance to integrate their procedural understanding as well as their conceptual learning in order to appropriately respond to the questions. If the questions are designed to further student recall abilities, the questions represent "concept domain" questions and are at the lower end of the learning curve. If the questions require the students to "put together" the processes they have been learning with the concepts they have acquired, and require the students to apply the newly constructed understanding to a new and unique situation, they are application questions. Students must use higher order thinking skills in order to correctly respond.

One concern many teachers have is the development of criteria by which student work can be assessed. This concern is well-grounded, yet easily addressed. The key point is that application of concepts and processes will best be demonstrated in a new and unique situation. That situation can be devised by the teacher or the students; the situation, however, must be "real world" so that the students **want to investigate** the proposed situation. Following is a rubric developed by one local Iowa SS&C site to guide teachers' assessment of student applications.

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Teacher Observation Checklist

(Integrated Domain)

One example of assessment imbedded within the instructional phase of a unit or module addressing such issues as flooding, ecosystems, wetlands, water pollution, weather, and/or recreation is provided in the following paragraphs.

EXAMPLE: The students are given the activity provided on the following page. Have the students form cooperative groups and ask them to investigate the two questions provided in the activity. They may use any method on which they agree, and the solution must be in a form that can be presented to the whole class. The time frame the teacher provides for this activity can be decided upon by either the teacher or a vote by the students.

While the students are working on this investigation, the teacher may want to perform the imbedded assessment provided here.

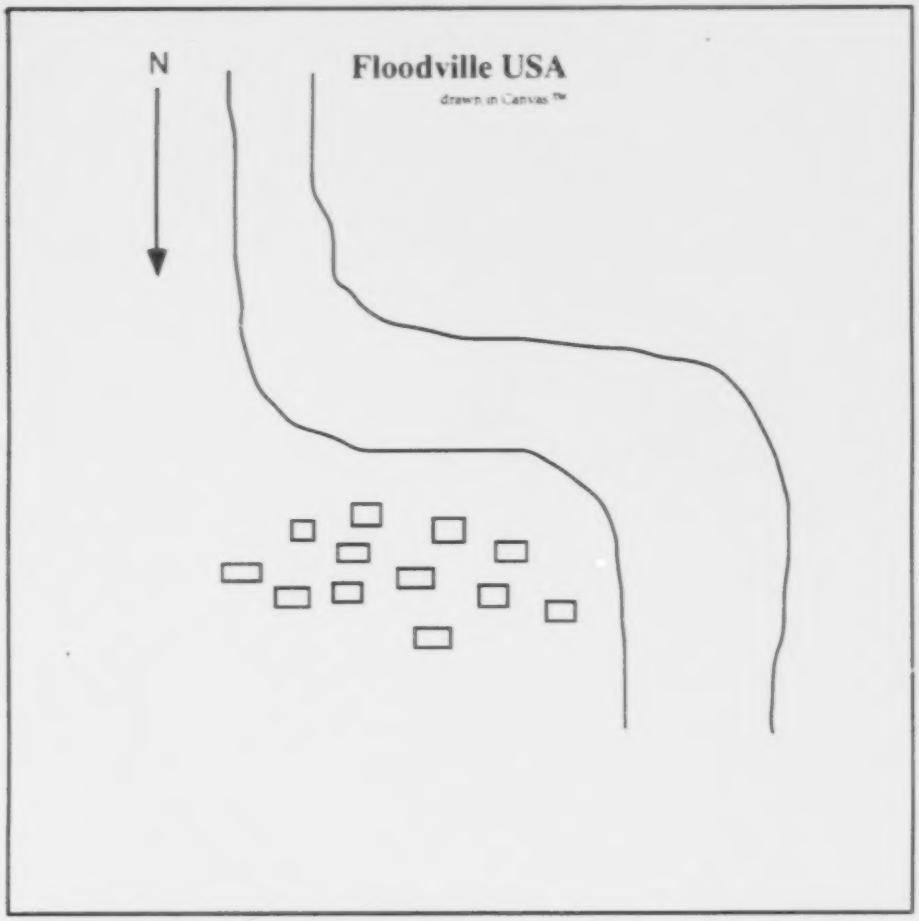
Assessed Behaviors	Number of Times Observed	Highlights
1. Students are actively discussing issue.		
2. Students are employing prior concepts to solve problem.		
3. Students are exhibiting a positive attitude.		
4. Students are demonstrating an understanding of scientific problem-solving.		
5. Students are employing interdisciplinary strategies to solve problem.		
6. Students use multi-disciplinary skills to present group solution.		
7. (additional observations...)		
8.		
9.		
10.		

This checklist can be placed on a 5x7 index card and carried by the teacher while circulating among the cooperative groups. When specific examples demonstrate any of the assessable activities is observed, a check can be placed in the appropriate location.

(Appropriate assessable activities may include: students talking about their own experiences thereby bringing prior knowledge into play; i.e. concepts may be overheard and shared by students; communication skills within groups can be observed; attitude of individual group members or entire groups may be noted; newly generated questions may develop in groups; creativity dealing with innumerable variables can be observed and noted. There are many more observations that can be noted depending on the prior criteria set up by the teacher and students.)

Floodville USA
(Creativity Domain)

One potential imbedded assessment piece that can be used by a teacher at any point during a module investigating such issues as flooding, ecosystems, wetlands, water pollution, weather, recreation, mapping skills economics, social problems, and government involvement.



1. What can be done to protect Floodville, USA if flooding will definitely occur?

2. What potential difficulties exist that will make any solution difficult?

3. How can those difficulties be dealt with by those interested in protecting Floodville, USA?

4. (teachers choice)

5. (students choice)

<u>Statement for discussion/debate:</u>
"Peole should not be permitted to build on flood plains."

Sample Assessment Items

(Application Domain)

Correct answers are indicated by an asterisk (*).

1. **Concept**: When water freezes, its volume increases.
   Application Question: Which one of the following is the main reason that water should not be stored in the freezer in a container which is totally filled and sealed?

   A) The taste of the water will change.
   B)* The container might break as the water expands.
   C) The water reacts with the glass at very low temperatures.
   D) Water will not freeze because there is not enough space available for it to convert into ice.

2. **Concept**: The time it takes to warm an object which is in a boiling liquid depends on the amount of material making up the object, and how much of its surface is exposed to the boiling liquid.
   Application Question: In which of the following situations will the potatoes cook most slowly in boiling water?

   A)* A single one pound potato.
   B) One pound of small potatoes.
   C) One pound of medium potatoes.
   D) One pound of potatoes cut into small pieces.

3. **Concept**: Most bird identification guides are based on knowledge of a bird's shape, size, color and patterns of markings.
   Application Question: While sitting at the breakfast table on a winter morning, you notice a species you have never seen before. What step would you recommend to best guarantee that you will be able to identify the bird?

   A) Make a note of the bird's favorite food.
   B) Observe the behavior of the bird.
   C)* Carefully study size and coloration.
   D) Determine sex of the bird.

4. **Concept**: The temperature at which water boils decreases with altitude, therefore the temperature of boiling water at high altitudes will not be as high as the temperature of boiling water at sea level. A pressure cooker is a kitchen appliance where high pressure and high temperature are maintained inside the cooker despite the altitude.
   Application Question: Where would it be more efficient to have a pressure cooker for cooking food?

   A) At sea level.
   B)* In the high mountains.
   C) Below sea level.
   D) When it is very cold outside.

5. **Concept:** It takes a large amount of heat energy to evaporate water therefore, evaporation is used as cooling process.

Application Question: Out on a camping trip, which of the following situations would result in providing the coldest drinking water if the water in each case started out at the same temperature?

A) Metal canteen filled with water and kept in the shade.
B)* Metal canteen with wet cloth-covered sides, filled with water, and kept in the shade.
C) Metal canteen filled with water immersed in a bucket of water at same temperature as the interior water, and kept in the shade.
D) Metal canteen filled with water and kept in direct sunlight.

6. **Concept:** Light colored objects reflect sunlight better than dark colored objects.

Application Question: During a sunny winter day, which vehicle would be the warmest to the touch?

A) A blue car.
B) A red car.
C) A white car.
D)* A black car.

7. **Concept:** In very cold conditions up to 80 percent of the heat made by the body can be lost through the surface of the head and neck.

Application Question: Which would be the best way to preserve the greatest amount of body heat if you were suddenly caught outside in below zero weather and all you had to wear were boots, shorts, a T-shirt and light jacket?

A) Wrap the jacket around the uncovered portion of your legs.
B) Leave the jacket on as you usually wear it.
C)* Wrap the jacket around your head and neck.
D) Use the jacket to keep the nearby air moving.

8. **Concept:** Objects with a large ratio of surface area to volume will cool down faster than objects with a small ratio of surface area to volume.

Application Question: Suppose a waiter brings you cooked steak, which is the best way to keep it as warm as possible while you eat it?

A)* Cut only the piece to be eaten.
B) Cut the steak quickly into mouth-size pieces.
C) Keep air moving near the steak.
D) Eat slowly.

9. **Concept**: Warm blooded animals lose body heat in proportion to their surface area and generate it in proportion to their weight.
Application Question: Which of the following animals would need to eat more per gram of body weight?

A)* A mouse.
B) A dog.
C) A cow.
D) A cat.

10. **Concept**: When most metal objects are heated, they increase in size.
Application Question: What are you assuming when you put the metal lid of a glass containing under warm water to loosen it?

A) Both glass jar and metal lid increase in size in the same proportion.
B) Glass increases in size in a greater proportion than the metal lid.
C)* The metal lid increases in size in a greater proportion than the glass.
D) Glass and metal do not stick together as much in water.

11. **Concept**: When most metal objects are heated, they increase in size.
Application Question: If a nickel with a hole in it is heated, what will happen to the size of the hole?

A) Decrease in size.
B) Stay the same.
C)* Increase in size.
D) Become irregular.

12. **Concept**: Steam has the same temperature as boiling water itself, but it has stored energy that is released when it condenses back into water.
Application Question: Which of the following will be more harmful?

A) A burn with boiling water.
B)* A burn with steam.
C) A burn from condensed water.
D) A burn from heated rain water.

13. **Concept**: When compared with other materials, water can absorb great amounts of heat while not greatly changing its temperature.
Application Question: Which of the following is best explained by the idea that water can absorb great amounts of heat?

A) Why lakes freeze from the top down.
B) Why ice floats in water.
C)* Why cities which built near large bodies of water have moderate climates in relation to other cities along the same latitude.
D) Why ice is so prevalent at both the North and South Poles.

14. **Concept**: The color of an object is determined by the wavelengths (colors) of light which is reflects and those it absorbs.

Application Question: Which of the following best explains why most plants are green?

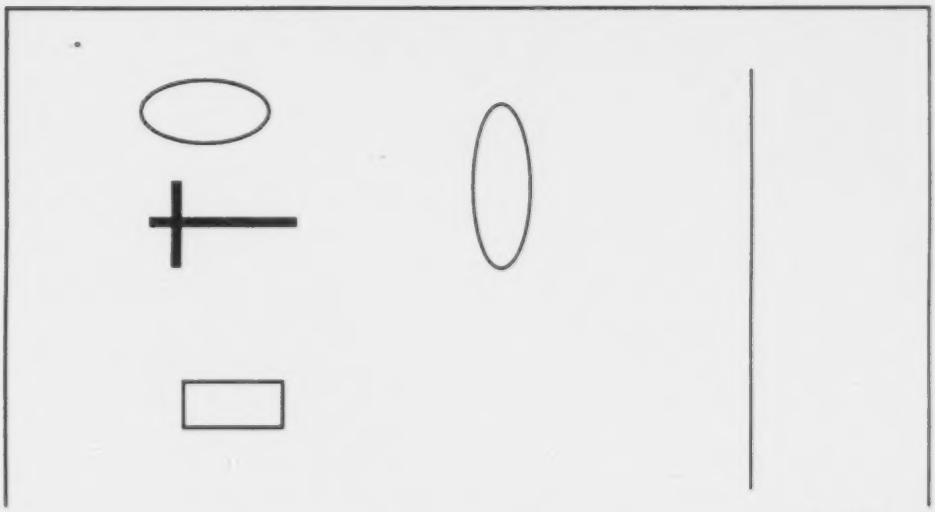
A)* A substance which reflects green light is a major part of the plant.
B) Green light is used by the plant.
C) Only green light is absorbed by plants.
D) All light, except for the green light, affects plant growth.

Assessment Examples for the Creativity Domain

(Creativity Domain)

In this example, students may have been studying forest ecosystems, biomes, photosynthesis or soil erosion. This could be used as a pre-assessment of creativity as well as a post assessment..

A forester was making a drawing of a forest.This is as far as she got. It's your job to complete it in any way you wish. There is no wrong way to do it.



(P. Veronesi, 1993)

Creative writing is another way of assessing creativity in students. Concepts can be gleaned from this type of assessment as well. Following is an example of a situation that students can use their imagination and incorporate as many or as few concepts as the teacher deems necessary.

Elementary: "What would the world be like if it rained chocolate drops?"

Secondary: "What would happen if lakes became frozen from the bottom?"

Assessing Creativity Using Creative Situations

(Creativity Domain)

It is recommended that the following situation statements be related to the unit of instruction so that the students can see the relationship between the assessment and what they are studying. Care should be taken, however, to insure that the unit of instruction does not center on the situation statement to such an extent that this measure of creativity becomes a test of knowledge.

Teachers may want to obtain written responses from their students in relation to the concepts being studied.

Sample situation statements used in the past have included the following:

First grade:	"Bobby woke up and found dinosaurs in his yard."
	Other:
Third grade:	"Suppose we lived in a world without insects."
	Other:
Fifth grade:	"Pretend that there was no more pollution."
	Other:
Seventh grade:	"Suppose there was no more disease in the world."
	Other:
General:	"Jane stopped at the gas station to obtain fuel for her car. To her dismay she was not able to get any."
	Other:

One Way to Score Your Creativity Assessment Instrument

1. The rationale behind this measure is to provide a thought-provoking situation appropriate to the ability and experiences of the students to be assessed and have students write as many pertinent and imaginative responses to the situation as possible. The number of such responses will provide a clue to their overall creativity. This test is designed to assess creativity by examining two factors—the number of questions asked and statements made by the student, and the quality (and/or uniqueness) of those questions and statements.

   There are three activities which together will help assess student creativity. Students will be instructed to ask questions, guess causes, and predict consequences relative to the situation statement.

2. One needs enough sets of the Assessment of Creative Thinking—Student Response Sheets for each individual taking the test. Include the situation statement in the space on the first page of the student response sheet set before it is duplicated.

   It is recommended that the situation statement be related to the unit of instruction so that the students can see the relationship between the assessment and what they are studying. Care should be taken, however, to insure that the unit of instruction does not center on the situation statement to such an extent that this measure of creativity becomes a test of knowledge.

3. Hand out one set of the Student Response Sheets to each student, and read the following to try to arouse the group's interest for the activity. Students should be instructed not to open the booklet until told to do so.

   "We are going to do some things that will give you a chance to see how good you are at thinking up new ideas and solving problems. We will be calling for all the imagination and thinking ability you have. This is not a test in the usual sense, but really is a game so try to enjoy yourself." At the same time, it is one way we can determine how well we are meeting one kind of objective we have in science teaching.

   Continue by saying: "These activities will give you a chance to use your imagination in thinking up ideas and putting them into words. There are no right or wrong answers like there are in many things that we do. We want you to see how many ideas you can think of, and we think you will find this fun. Try to think of interesting, unusual, and clever ideas. It doesn't matter if you have the same ideas as other in the class or if you suggest something that no one else will think of."

   "You will have three different activities to do and you will be timed on each one, so make good use of your time. Work as fast as you can without rushing. If you run out of ideas before time is up, wait until instructions are given before going to the next activity. Sometimes if you will just sit and think, more ideas will come to you and you can add those on your list. If you have any questions after we start, raise your hand and I shall come to your desk and try to answer your questions."

4. Read the situation statement and the instructions for each of the activities to the class. Avoid giving examples or illustrations of model responses as this may tend to reduce originality and the number of responses produced.

5. Read the following: **"You will have five minutes for each of the three activities.** A signal will be given to end each activity, after which you are to proceed to the next activity. I will let you know how much time remains in each section. If there are no questions, you may begin."

6. While the students are working, you should enter each student's name or ID number on the Class Tabulation Sheets.

7. During work on each section, write the number of minutes remaining on the board at least once per minute.

8. When time is up, collect the student response booklets and score them using the following guidelines. It is suggested that you read through these guidelines several times before you begin.

   There is certainly a great deal of judgment involved in the scoring, but since the same person will be evaluating both pretests and posttests, this factor should remain constant.

   The best way to make the distinction between unique and pertinent responses is to review all the response sheets before making the final decision. Suppose the students are asked to respond to the situation question that "Bobby woke up and found dinosaurs in his front yard." If one student indicates that this occurred because the Earth went through a time warp, this would certainly be considered unique, but if many students said that, the response would simply be pertinent. There may be a common experience, such as a cartoon show, which has produced the high frequency of this particular response. You can only make the determination of frequency by examining all of the student response sheets first.

   Scoring in this section refers to the **creative strength** expressed in a particular response based on your experience with children. Consult the following criteria as guidelines to help in the scoring of this section:

   Evaluate each statement the student makes by entering **I**, **P**, or **U** in the space marked score code. Several examples of students responses with the appropriate score are shown below:

   Statement: Suppose you got up one morning and found that there was no gravity.

   I = Irrelevant: The student's response is not related to the question.
   Example: Dogs will chase cats.

   P = Pertinent: The student's response is related to the question but is not particularly creative.
   Example: We would float away.

   U = Unique: The student's response is related to the question and is very creative.
   Example: We would be able to jump very high to pick fruit from trees.

   Student responses which are unique would also be pertinent, but use only the U symbol in these cases. Other responses, which are not applicable to the question, would be given an "I" and not used in computing a test "score".

Count the total number of pertinent responses **(P)** and the total number of unique **(U)** statements in each section (Questions, Causes, or Consequences). Put these numbers in the appropriate boxes on the **Class Tabulation Sheets** (Pretest).

9. Total each column and then calculate a class average.

10. Following your unit, give the same test again as a posttest. Score and analyze the posttest and fill out the appropriate spaces on the **Class Tabulation Sheets** (Posttest). An examination of the class averages on the pretest and posttests will indicate growth in the class as a whole.

11. On each **Class Tabulation Sheet** determine growth in each of the three areas by subtracting pretest from posttest scores for each student.

    If assessment in this domain is used generally, you will certainly want to share the results with students after the first pre-posttest effort. Students tend to learn when they can see the goal and understand the purpose for assessment. Also, such assessment must seem related to the curriculum (the STS module) and to the instructional strategies used. Students should be encouraged to take pride in their creative abilities. Teachers can stimulate creativity by providing creative challenges in science throughout the year.

Assessment of Student Creativity—Student Response Sheets

Name: _____
Teacher's Name: _____
Age: _____ Grade: _____ Gender: _____ Date: _____

The three activities in this exercise will be based on the situation described below. These activities will give you a chance to see how good you are at asking questions to find out things that you don't know and in making guesses about possible causes and consequences of happenings. What is happening? What can you tell for sure? What do you need to know to understand what is happening, what caused it to happen and what will be the result?

Situation Question:

Third grade: "Suppose we lived in a world without insects."

Other:

ASKING QUESTIONS: On this page write all of the questions you can think of that will help you understand the situation described above. List all the questions you would need to ask, or want to know to be sure what is happening.

SCORE
CODE

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____

SUGGESTING CAUSES: On the lines below, list as many possible causes as you can for what is described in the situation. *You may think of things that might have* happened just before what has happened in the description, or something that happened a long time ago that made these happen. Other as many ideas as you can.

SCORE
CODE

_____ 1. _____
_____ 2. _____
_____ 3. _____
_____ 4. _____
_____ 5. _____
_____ 6. _____
_____ 7. _____
_____ 8. _____
_____ 9. _____
_____ 10. _____
_____ 11. _____
_____ 12. _____
_____ 13. _____
_____ 14. _____
_____ 15. _____
_____ 16. _____
_____ 17. _____

PREDICTING CONSEQUENCES: On the lines below, list as many possibilities as you can of what might happen in the future as a result of what is taking place in the situation. You may use things that might happen right afterwards or things that might happen as a result long afterwards in the future. Make as many predictions as you can. Don't be afraid to be creative in your responses.

SCORE
CODE

_____ 1. _____
_____ 2. _____
_____ 3. _____
_____ 4. _____
_____ 5. _____
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_____ 17. _____

Assessing Creativity Using Comparisons

(Creativity Domain)

(Adapted from Williams, Stockmyer, and Williams, 1984)

The person administering this assessment will ask the question **(or one similar)**:

"How is a school like an island?"

The test takers are encouraged to record their responses in as much detail as possible. (The teacher and students can decide the concepts to be addressed prior to assessment.)

Possible evaluation scheme:

To differentiate "high creativity answers" from "low creativity answers", the following criteria may be used:

1. Validity

   A response referring to a condition which constituted a potential similarity between school and an island gets one point.
   A response which notes a contrast instead of a comparison or states something which could not, in any reasonable way, be considered true, gets no points.

2. Distinctiveness

   A response illustrating both school and an island and indicating a direct knowledge of the basis of comparison as opposed to merely referring to a general condition gets one point.

3. Diversity

   A response drawing a comparison that crosses categorical lines, thereby demonstrating an awareness of remote connections between the stated terms, or one that includes categories that may be human, man-made, animal, natural, or any decided upon by the students and teachers, or one which relates developments, processes, or conditions of one category to those of another gets one point.

4. Abstraction

   A response involving an abstract as opposed to a concrete similarity gets one point.

Total Score

1-2 points—low creativity
3-4 points—high creativity

Drawing Production as a Creative Thinking Assessment

(Creativity Domain)

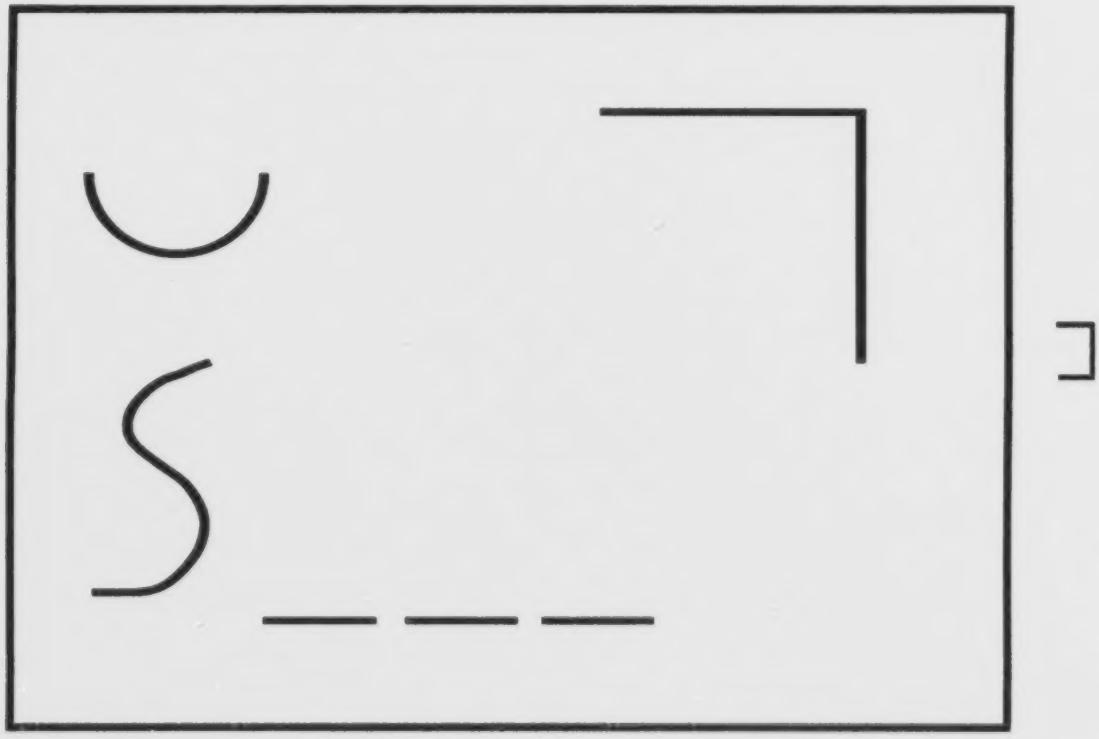
(Adapted from Jellen and Urban, 1986)

Many times creativity in science is ignored in the traditional science classroom. Practicing scientists use their creative abilities daily. Creativity assessment lends itself to the characteristics possessed by those involved with science. It is also necessary for problem solving in real-life situations that occur everyday.

When teachers are administering this assessment, they are encouraged **not** to make any reference to time, and to write the time taken by the student at the top of the page. The introduction to the test given to the students may go something like this:

"In front of you is an incomplete drawing. The artist who started it was interrupted before he or she actually knew what should become of it. You are asked to continue with this incomplete drawing. YOU ARE ALLOWED TO DRAW WHATEVER YOU WISH. You can't do anything wrong. Everything you put on the paper is correct. When you finish with your drawing, please hand it in to me."

Age_____ Gender Name/Initials_____



Potential Scoring Ideas:

Drawing Production (DP) allows students of most ages and ability groups to interpret and to complete what they conceive to be significant for the development of a creative product. It is seen as an important addition to the culture-fair assessment of creative potential (Jellen & Urban, 1986). Eleven criteria serve as the evaluation process to assess creativity in a drawing production. They are interacting entities reflecting a holistic concept to creative thought.

Creativity can be evaluated in a drawing production in a very economical way since:

- The cost is relatively low when compared with similar tests;
- The timing in administering and evaluating the test is minimal (i.e., the testing procedure requires 15 minutes and the evaluation procedure approximately three to five minutes per case);
- The instrument can be applied to different age as well as ability groups;
- The administration and evaluation of the test requires very little training (Jellen & Urban, 1986).

The DP construct is also supported by those components of creative thought that can be found throughout the existing literature on creativity and creativity testing. The components are: 1) fluency; 2) flexibility; 3) originality; 4) elaboration. Three other components of creativity can also be assessed via this instrument; they are: 1) risk-taking (i.e., boundary-breaking); 2) composition (i.e., coherence of organization); 3) humor as a cognitive-affective ability capable of freeing the mind from concrete or unpleasant realities (Jellen & Urban, 1986).

There are eleven key elements which serve as evaluation criteria for the TCT-DP:

1. Completion (Cm)—Any continuation and extension of the six figural fragments. One point for each continuation. Point value: six points maximum.

2. Additions (Ad)—Any additions made to the extended or continued figural fragments (e.g., points, lines, patterns, etc.). One point for each addition. Point value: six points maximum.

3. New elements (Ne)—Any new figure, symbol or element created in addition to, but independent of, the given figural fragments. One point for each connecting line. Point value: six points maximum.

4. Connections made with a line (Cl)—Any drawing connection made with a line between one figural fragment or figure and another. One point for each connecting line. Point value: six points maximum.

5. Connections made to produce a theme (Cth)—Any figure contributing to a compositional theme. One point for each theme-bound figure. Point value: six points maximum.

6. Boundary-breaking that is fragment-dependent (Bfd)—Any extension or continuation of the "small open square" located outside the square frame. Point value: six points.

7. Boundary-breaking that is fragment-independent (Bfi)—Any drawing independent of the "small open square" that breaks the square frame or is located outside of it. Point value: six points.

8. Perspective (Pe)—Any breaking-away from two-dimensionality. One point for each figure; six points for a perspective solution contributing to a compositional theme with perspective. Point value: six points maximum.

9. Humor (Hu)—Any drawing which elicits a humorous response. Point value: six points maximum.

10. Unconventionality (Uc)—Any manipulation of material (e.g., the turning of the testing paper [3 points]). Any surrealistic and/or abstract elements (e.g., the utilization of an abstract theme [3 points]). Any combination of figures, signs, and/or symbols (e.g., the semi-circle does not become a stereotypical sun or face [3 points]). Point value: twelve points maximum.

11. Speed (Sp)—A break-down of points according to the time spent on each drawing production:

    Under two minutes—6 points;
    Under four minutes—5 points;
    Under six minutes—4 points;
    Under eight minutes—3 points;
    Under ten minutes—2 points;
    Under twelve minutes—1 point.

All test sheets must be collected after 15 minutes. The highest score possible on the TCT/DP is 72 points (Jellen & Urban, 1986).

Scoring

Cm					_____
Ad					_____
Ne					_____
Cl					_____
Cth					_____
Bfd					_____
Bfi					_____
Pe					_____
Hu					_____
Uc	_____+	_____+	_____+	_____=	_____
Sp					_____
DP Total					---------

Science, Technology & Society Attitude Scale

(Attitude Domain)

(adapted from National Assessment of Educational Progress, 1977)

Grade Level _____ **Student Number** _____

Teacher _____ **School** _____

For each sentence, mark the letter which indicates your view or the most accurate response.

1. Gender: a = female b = male a b
2. Ethnicity: a = Asian b = African-American a b c d e
   c = Hispanic/Latin d = Caucasian
   e. = Native American/Alaskan Native
   Other (please write in) _____

For statements 3-20 mark the letter indicating your view, use the following rating scale:

a = Strongly Agree b = Agree Moderately c = Neutral
d = Disagree Moderately e = Strongly Disagree

	Strongly Agree	Agree Moderately	Neutral	Disagree Moderately	Strongly Disagree
3. Problems resulting from science or technology hardly ever affect me.	a	b	c	d	e
4. Most people will not act on STS issues even if they understand why action is necessary.	a	b	c	d	e
5. All Science classes should incorporate STS issues and topics into the present curriculum.	a	b	c	d	e
6. I would be willing to pay 10% more per product if manufactures would use this money to reduce their pollution.	a	b	c	d	e
7. Science content is the most important aspect of STS education.	a	b	c	d	e
8. I know all I care to know about environmental problems.	a	b	c	d	e
9. STS education should incorporate a problem solving approach.	a	b	c	d	e
10. The government is really trying to solve our Science, Technology and Society problems.	a	b	c	d	e
11. Open discussion should be a major component of STS curriculum.	a	b	c	d	e
12. In the future, there will not be any problems resulting from Science or Technology in the United States.	a	b	c	d	e
13. Science process skills should be used whenever possible when teaching STS topics.	a	b	c	d	e
14. I want to know how STS issues impact me.	a	b	c	d	e
15. Members within a society have the responsibility to develop an appreciation of, and respect for, the rights of others within the society.	a	b	c	d	e
16. I would like more information on pollution.	a	b	c	d	e

17. If I knew more about STS issues, I would do more about them.	a	b	c	d	e
18. Declining environmental quality poses a serious threat to the future health and well being of most Americans.	a	b	c	d	e
19. Technology eventually will solve all our problems.	a	b	c	d	e
20. Consumers like myself are <u>really trying</u> to solve the problems dealing with Science, Technology and Society.	a	b	c	d	e

Assessing Attitudes and Preferences in Science (Grades 4-12)
(Attitude Domain)

Grade Level _____ **Student Number** _____
Teacher _____ **School** _____

For each sentence, mark the letter which indicates your view or the most accurate response.

1. Gender: a = female b = male a b
2. Ethnicity: a = Asian b = African-American a b c d e
   c = Hispanic/Latin d = Caucasian
   e. = Native American/Alaskan Native
   Other (please write in) _____

For statements 3-20 mark the letter indicating your view, use the following rating scale:

a = always b = frequently c = sometimes d = rarely e = never

A = Always, F = Frequently, S = Sometimes, R = Rarely, N = Never

		A	F	S	R	N
3.	Science classes are fun.	a	b	c	d	e
4.	Science classes increase my curiosity.	a	b	c	d	e
5.	The things studied in science classes are useful to me in daily living.	a	b	c	d	e
6.	Science classes help me test ideas I have.	a	b	c	d	e
7.	My science teacher frequently admits to not having answers to my questions.	a	b	c	d	e
8.	Science classes provide me with skills to use outside of school.	a	b	c	d	e
9.	My science class deals with the information produced by scientists.	a	b	c	d	e
10.	Science classes are exciting.	a	b	c	d	e
11.	Science classes provide a chance for me to follow-up on questions I have.	a	b	c	d	e
12.	Science teachers encourage me to question.	a	b	c	d	e
13.	All people can/do/practice basic science.	a	b	c	d	e
14.	Being a scientist would be fun.	a	b	c	d	e
15.	Being a scientist would make a person feel important.	a	b	c	d	e

Alternative

16.	Science classes are boring.	a	b	c	d	e
17.	Being a scientist would be lonely.	a	b	c	d	e
18.	Being a scientist would make a person rich.	a	b	c	d	e
19.	Being a scientist would mean giving up some of the things of interest.	a	b	c	d	e
20.	Scientists discover information that is difficult to understand.	a	b	c	d	e

For items 21-28 mark "a" for the subjects you like and mark "b" for the subjects you do not like. Then, circle the title of your favorite subject.

21. Foreign Language	a	b	25. Physical Education	a	b
22. Science	a	b	26. Language Arts	a	b
23. Mathematics	a	b	27. Reading	a	b
24. Social Studies	a	b	28. Music	a	b

Science Process Test

(Adapted by Mason City Schools, August 1993)

Name _____

Student Number (ID #) _____
Teacher _____ **Course** _____

Are you using a scantron sheet? Circle one: yes no

1. Gender:	a = female b = male		a b
2. Ethnicity:	a = Asian b = Black c = Hispanic/Latin d = Caucasian e = Native American/Alaskan Native Other (please write in) _____		a b c d e
3. Grade:	a = 6, 7, 8 b = 9 c = 10 d = 11 e = 12		a b c d e

For each question, mark the letter which indicates your view of the most accurate response.

Making Observations

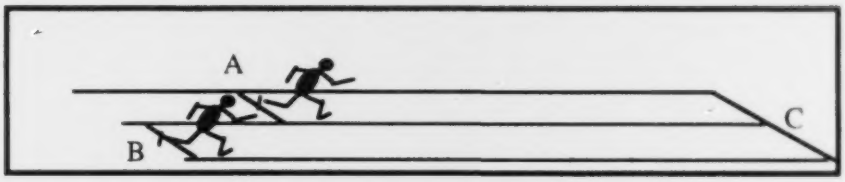
4. Which of the following is an observation only? The

   A) piece of metal is red so it must be hot.
   B) street is wet, so it must have rained.
   C) table looks like it is made of wood.
   D) child's block is orange.

5. Which of the following could be observed with the sense of sight? A

   A) change in temperature of the air.
   B) change in height of plants.
   C) change in sweetness of a new chemical.
   D) change in the noise made by an engine.

Using Space/Time Relationships

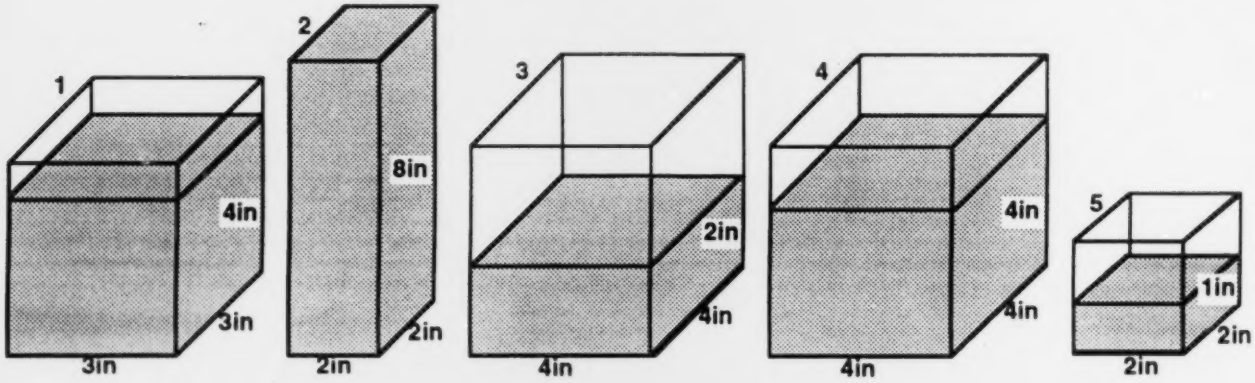


6. If runners A and B start at the same time, and they arrive at the finish line (C) at the same moment, who runs faster?

   A) A is faster than B.
   B) B is faster than A.
   C) A and B raced at the same speed.
   D) B is slower than A.

7. What shape of shadow could NOT be formed by using a complete cylinder?

   A) a circle
   B) a square
   C) a rectangle
   D) a triangle



8. According to the diagram above, which two containers have approximately equal volumes of water in them?

   A) 1 and 2
   B) 2 and 3
   C) 3 and 5
   D) 2 and 5

Classification

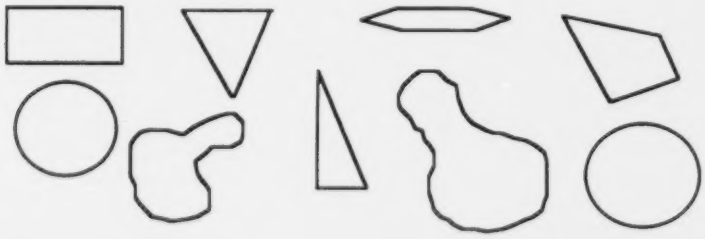
9. Here is some information about students in Maple Elementary School.

1 Name	2 Gender	3 Birthday	4 Nationality	5 Year Entered School
M. John	Female	June 1990	American	1995
B. Thames	Male	March 1990	British	1995
A. Shirley	Male	December 1989	American	1995
R. Thompson	Female	May 1990	American	1995
R. Ali	Male	October 1989	Indonesian	1995
B. Ghombal	Male	August 1989	Portuguese	1995

Which of the following categories would NOT allow you to separate these students into at least TWO different groups?

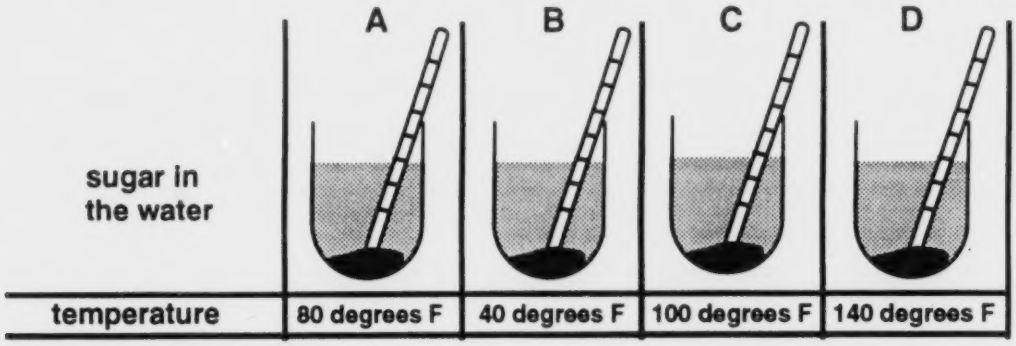
A) gender (male or female)
B) year of birth
C) nationality
D) year entered school

10. Which would be the best feature to use in classifying the following objects?



A) Square vs. not a square.
B) No straight sides vs. four straight sides.
C) Circle vs. triangle.
D) Curved edge vs. straight edge.
E) Odd number of sides vs. even number of sides.

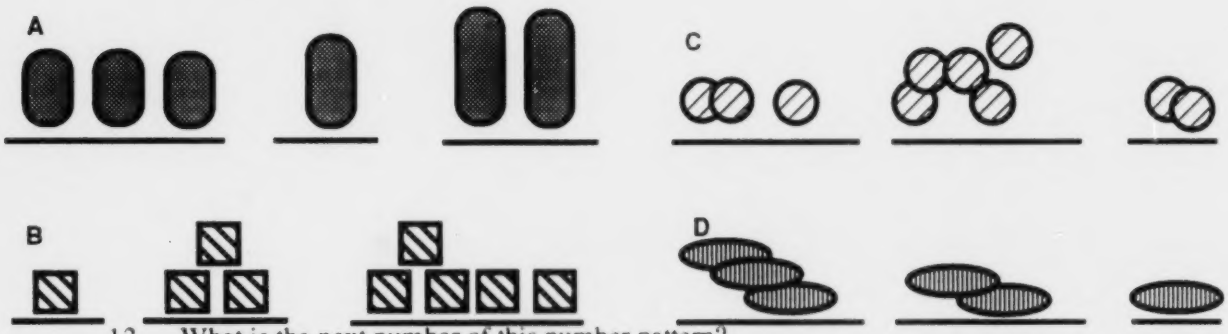
11. The hotter the water, the faster sugar will dissolve. Look at the jars. Each jar has the same amount of sugar. Put the jars in order from the slowest to the fastest dissolving.



A) A, B, C, D
B) B, A, C, D
C) C, B, D, A
D) D, C, B, A

Using Numbers

12. Which of the picture groups below shows the objects in order from the smallest to the largest number?



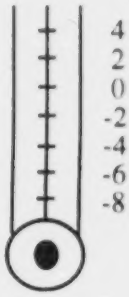
13. What is the next number of this number pattern?

2 3 5 8 12 17 ?

A) 19
B) 23
C) 24
D) 28

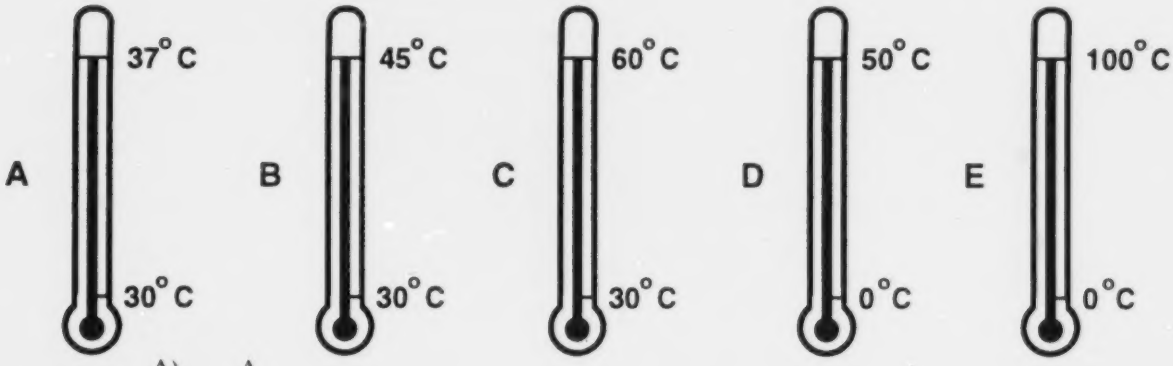
14. Yesterday is was -6° F. Today it is 2° F. How many degrees warmer is it today when compared with yesterday

A) 10°F
B) 8°F
C) 4°F
D) 2°F



Measuring

15. Normal human body temperature is 37°C. The body temperature of a sick person ranges from 36°C to 42°C. Which thermometer would be the best to use for measuring any human body temperature?



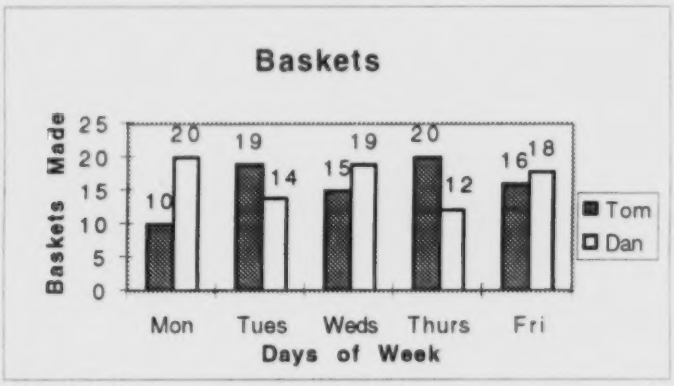
A) A
B) B
C) C
D) D
E) E

16. Four children were each given their own plant. Each child was told to measure the height of the plant four times during a single class period to practice their measuring skills. Here are the results. Which student do you think measured most carefully and precisely?

	Measurement Number			
	1	2	3	4
Rusty's plant	3 cm	6 cm	10 cm	8 cm
Mike's plant	4 cm	5 cm	5 cm	4 cm
Karen's plant	2 cm	10 cm	4 cm	8 cm
Carol's plant	8 cm	3 cm	2 cm	1 cm

A) Rusty
B) Mike
C) Karen
D) Carol

17. Here are the results of baskets made by Dan and Tom who each shot twenty foul shots each day for five days. On how many days did Dan make more baskets than Tom?



A) 1 B) 2 C) 3 D) 4 E) 5

Communicating

18. What object has six equal sides, 8 corners, 12 edges, and volume?

    A) cube
    B) square
    C) sphere
    D) cone
    E) hexagon

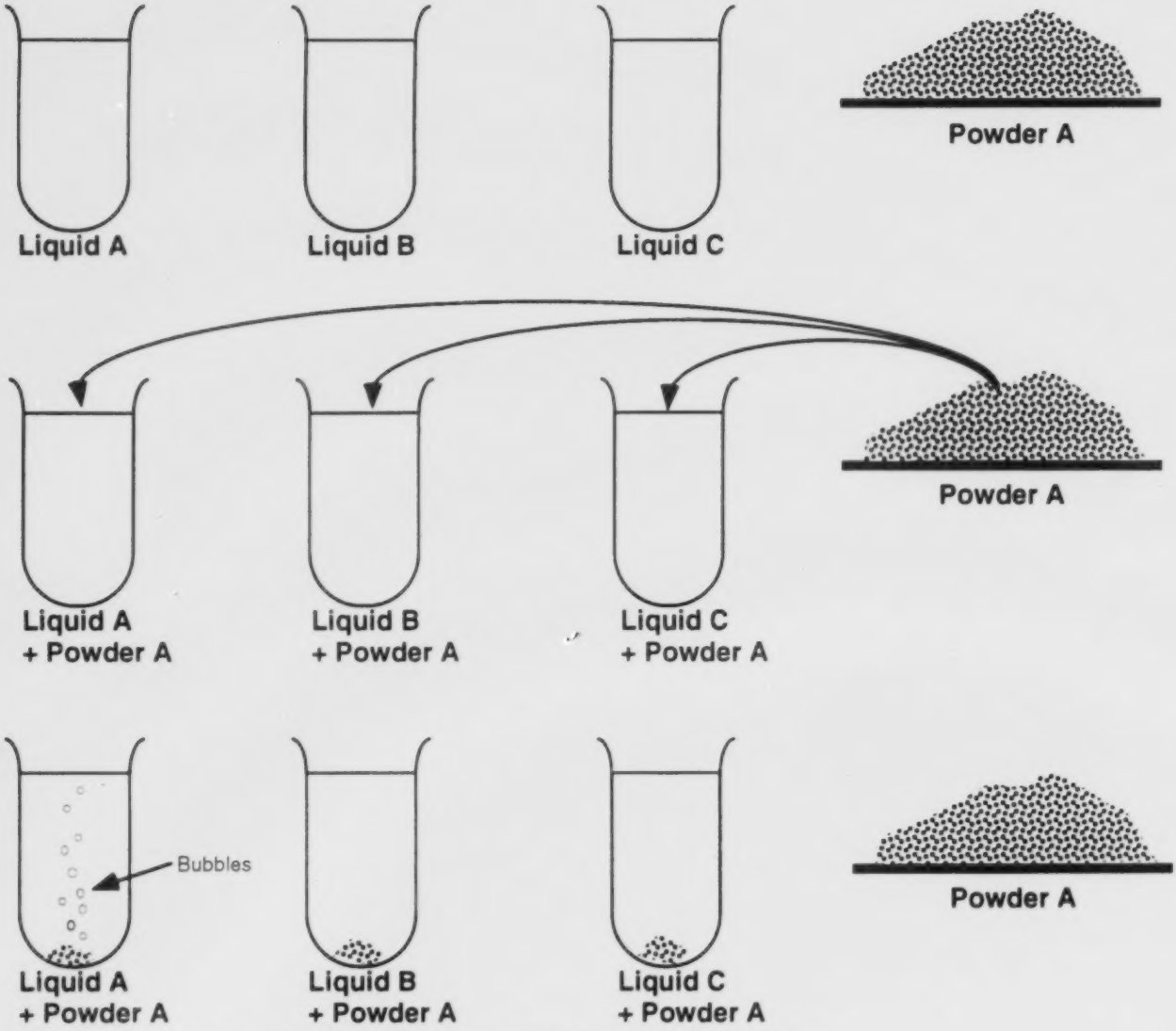
19. A tennis ball was dropped from several different heights, and the height the ball bounced was recorded each time the ball was dropped. Which of the following would be the best method to report the data collected? A

    A) written paragraph
    B) tally of the number of bounces
    C) frequency distribution
    D) bar graph
    E) pie chart

20. Mary wants to make a diagram of the school classroom on a piece of notebook paper. A convenient scale for her to use would be

    A) 1 inch = 1 mile.
    B) 1 inch = 1 centimeter.
    C) 1 inch = 1 yard.
    D) 1 inch = 1 acre.
    E) 1 inch = 1 inch.

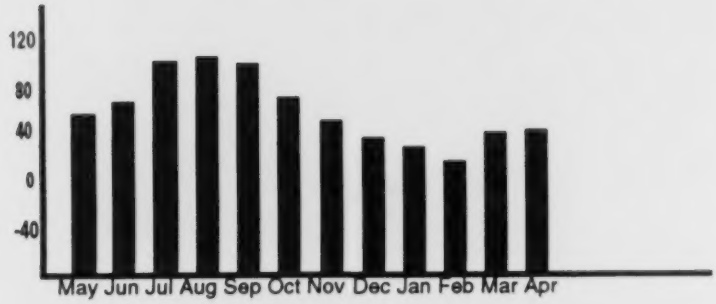
Making Inferences

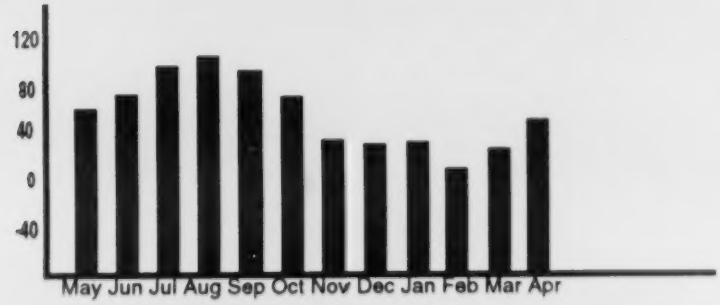


21. Which inference is best supported by the above conclusions?

A) Liquids A and C are the same.
B) Liquids A and B are not the same.
C) Liquids B and C are both the same.
D) Liquids A, B and C are all the same.
E) None of the above answers is correct.

Predicting

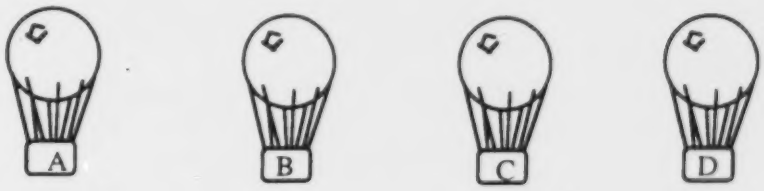




22. The average temperature recorded each month during the last ten years is shown on these graphs. Which month do you think will be coldest next year, based on the evidence?

A) June
B) September
C) November
D) January
E) February

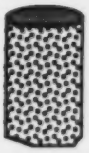
23. If the same amount of a gas is in the following balloons, which balloon do you think will float up the fastest?



weight: A) 1000 pounds B) 800 pounds C) 500 pounds D) 200 pounds

24. Look at the pictures below. Which item do you think will sink fastest in a pan of water?

A)



an empty can

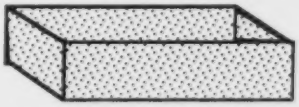
B)

a glass marble

C)

a wood box

D)



a piece of sponge

Controlling Variables

25. Dan and Dawn want to know if there is any difference between the mileage expected from bicycle tires from two different manufacturers. Dan will put one brand on his bike and Dawn will put the other brand on her bicycle. Which of the following variables would be MOST important to control in this experiment?

A) The time of day the test is made.
B) The number of miles traveled by each type of tire.
C) The physical condition of the cyclist.
D) The weather condition.
E) The weight of the bicycle used.

26. A group of students conducted an experiment to determine the effect of heating on the germination (sprouting) of sunflower seeds. Which of the variables listed below is LEAST important to control in this experiment?

A) The temperature to which the seeds are heated.
B) The length of time the seeds are heated.
C) The type of soil used.
D) The amount of moisture in the soil.
E) The size of the container used for growing each seed.

27. A student wants to know how the amount of acid rain affects the fish population. She takes two jars and fills each of the jars with the same amount of water. She adds fifty drops of vinegar (acid) to one jar and adds nothing extra to the other. She then puts 10 similar fish in each jar. Both groups of fish are cared for (oxygen, food, etc.) in identical fashion. After observing the behavior of the fish for a week she makes her conclusions. What could you suggest to improve this experiment without adding another variable?

A) Prepare more jars with different amounts of vinegar (acid).
B) Add more fish to the two jars already in use.
C) Add more jars with different kinds of fish and different amounts of vinegar (acid) in each jar.
D) Add more vinegar (acid) to the two jars already in use.

Interpreting Data

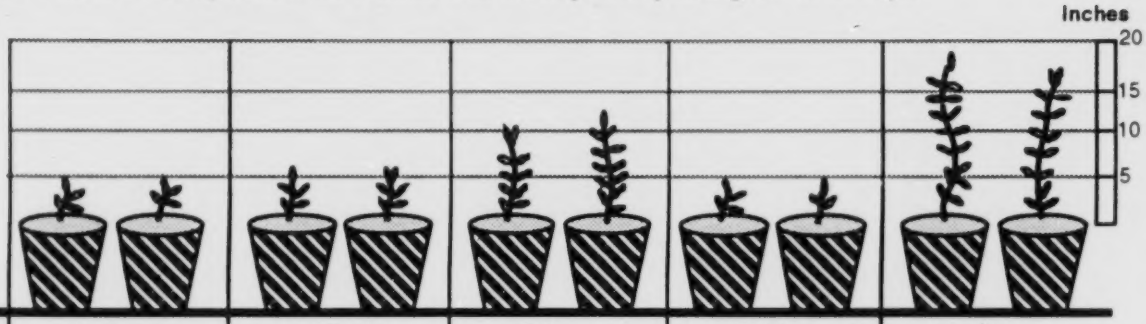
28. The following data are taken from an experiment:

Temperature (average)	Seed Weight (gram)	Water Consumed (ml/day)	Exposure to Light (min./day)	Plant Height (cm/20 days)
20°C	2.2	10	20	20.2
50°C	2.3	10	20	20.3
30°C	2.3	10	20	20.2
25°C	2.1	10	20	20.3
25°C	2.3	10	30	21.9
25°C	2.2	10	40	22.8
20°C	2.2	10	30	21.8
20°C	2.1	20	30	21.9
20°C	2.2	30	30	22.0

Based on the data above, what factor do you think influences the speed of the plant growth most?

A) The temperature where the plant is grown.
B) The seed weight.
C) The amount of water consumed every day.
D) The length of the period the plant is exposed to the light.

29. Here is an experiment that shows how much peanut plants grew in 20 days.



Data

Growing Time	20 Days	20 Days	20 Days	20 Days	20 Days
Amount of Plant Food Added	2 grams	2 grams	2 grams	2 grams	2 grams
Water Added	50 ml/day	75 ml/day	100 ml/day	60 ml/day	150 ml/day

Look at the chart above. What conclusions could you make from this experiment?

A) The more plant food added, the faster the plant grew.
B) The more water added with a certain amount of plant food, the faster the plant grew.
C) The more water added with a certain amount of plant food, the slower the plant grew.
D) The more plant food added with a certain amount of water, the slower the plant grew.

Formulating A Hypothesis

30. Bob set up two identical bowls which both contained sugar water and both were open to the air. One was put in the dark while the other was put in the light. What is the one item that is different from one set-up to the other? The

A) exposure to light.
B) shape of the bowl.
C) exposure to air.
D) amount of sugar in each.

31. Which of these statements best represents a hypothesis?

A) This magnet picked up twelve paper clips.
B) The milk in this bottle froze in twenty minutes.
C) The house plant may have died from being watered too much.
D) The leaves on that maple tree have all turned red.
E) At that rate, the pool filled in ten minutes.

32. Examine the data table below and select the most appropriate hypothesis regarding dissolving time and water temperature.

	Average dissolving time (in seconds)			
Substance	Water 20°C	Water 40°C	Water 50°C	Water 60°C
20 g of sugar	80	40	20	5
20 g of salt	60	30	16	3

A) There is no difference in dissolving time of the substances due to water temperature.
B) The lower the temperature of water, the shorter would be the dissolving time of the substances.
C) The higher the temperature of the water, the shorter the dissolving time of the substances.
D) It is impossible to make a hypothesis from the information given in the chart.

Defining Operationally

33. Which one of the following IS written as an operational definition?

A) Since the density of oil is lower than water, when water is mixed with oil, the oil will float on the surface of the water.
B) The speed of a supersonic jet is similar to the speed of sound waves.
C) When you drive your car at a speed of 30 miles per hour you have to push the brake pedal 300 feet before the line or point you are planning to stop.
D) The speed of a car will decrease when it has to turn right or left.

Experimenting

34. A student wants to test to see if the color of cloth influences the amount of heat absorbed. He plans an experiment using two colors of cloth to wrap two different glasses each containing the same amount of water. One glass is wrapped with green cloth, and the other is wrapped with yellow. He puts them under the sun's rays and puts a thermometer in each glass to observe the temperature. What things can you suggest to improve his testing?

A) To add to the number of glasses to be covered with the cloth.
B) To reduce the amount of water in each glass.
C) To prepare more containers each covered with a different color of cloth.
D) To double the size of the cloth used to cover the glass.

35. Eight bean seeds were germinated, then divided into four groups of two seeds each. One group was grown under red light, another under green light, another under blue light, and the fourth under ordinary white light. At the end of two weeks the growth of each group of plants was measured to see which group of plants had grown the most. This experiment could <u>best</u> be improved by?

A) Giving more water to the plants grown under the red light.
B) Increasing the number of seeds grown in each of the four groups.
C) Growing just the plants under white light in sandy soil, but growing all others in humus soil.
D) Adding one more group of two seeds to the experiment and growing them under purple light.

36. Gloria wants to determine the temperature best suited for fish. Which of the following procedures should she use to determine this?

A) Get 6 aquariums (fish tanks), put 6 similar fish in each in each aquarium and keep the temperature in each aquarium constant at 25°C.
B) Put 6 fish in one aquarium. At intervals of 10 minutes, change the water temperature from 10°C to 15°C; to 20°C; to 25°C; to 30°C; and finally to 40°C. Observe the behavior of the fish after each change in temperature.
C) Get 6 aquariums, put 6 similar fish in each aquarium, keep the temperature of the water constant at about 25°C, and observe the behavior of the fish in each aquarium.
D) Get 6 aquariums, put 6 similar fish in each aquarium with the temperature of the water varied from 15°, 20°, 25°, 30°, 35° to 40°C in each aquarium. Observe the behavior of the fish in each aquarium.

1990 NAEP Assessment Items for Nature of Science (Public Release)
(Concept and Nature of Science Domain)

* items for Grades 9-12

Grade Level _____ **Student Number** _____

Teacher _____ **School** _____

1. Gender:	a = female b = male		a b
2. Ethnicity:	a = Asian b = Black c = Hispanic/Latin d = Caucasian e = Native American/Alaskan Native Other (please write in) _____		a b c d e
3. Grade:	a = 6, 7, 8 b = 9 c = 10 d = 11 e = 12		a b c d e

For each question, mark the letter which indicates your view of the most accurate response.

4. Knowledge of Earth's past continues to change as scientists find additional fossils. This is because

A. scientific knowledge cannot be trusted.
B. scientists change their ideas as new evidence is found.
C. scientists do not accurately report what they observe.
D. fossil study is not a true science.

5. Which of the following statements about scientific knowledge is correct?

A. It is based on observations and experiments that can be repeated by scientists.
B. It cannot be tested.
C. It is based on laws that never change.
D. It is based on beliefs and faith.

6. Hypotheses are

A. ideas that can be tested.
B. facts about science.
C. observations of nature.
D. results of experiments.

7. Scientists estimate that Earth is about how many years old?

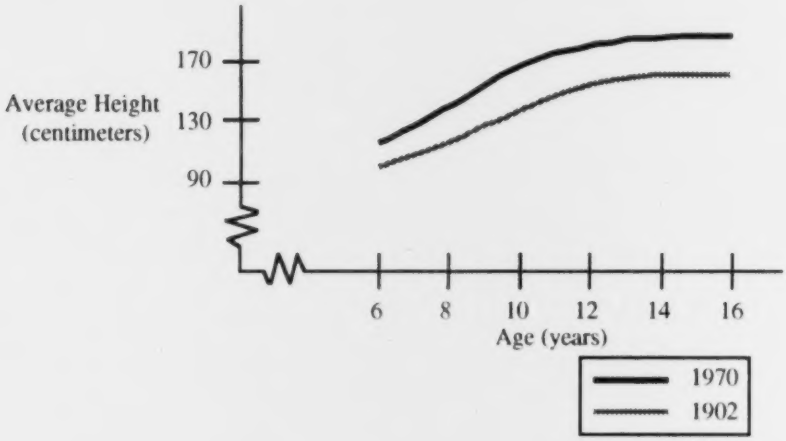
A. 100 billion
B. 5 billion
C. 60 million
D. 1 million
E. 10 thousand

8. The methods of science can be used to answer all of the following questions EXCEPT:

A. How many butterflies are there in California?
B. What are some of the effects of rainfall on the growth of roses in Kentucky?
C. Are roses more beautiful than butterflies?
D. Which brand of paper towels absorbs the most water?

9. Which of the following questions would be the easiest to answer with an experiment?

A. How many uses are there for magnets?
B. Which is the stronger of two magnets?
C. What makes a magnet strong?
D. How are magnets made?



10. What can you correctly conclude from the graph of children's' growth shown above?

A. On average, children in 1970 grew taller than children in 1902.
B. On average, children in 1902 grew taller than children in 1970.
C. There is no difference between 1902 and 1970 in the average height of children.
D. Younger children are taller than older children.

11. If José wants to find out how fast a pumpkin vine grows, which of the following should he do?

A. Sprout some pumpkin seeds in a cup.
B. Measure the longest pumpkin vine he can find.
C. Measure length of a pumpkin vine each week while it is growing.
D. Give one pumpkin vine more water and fertilizer than another pumpkin vine and compare the results.
E. Measure the diameter of the largest pumpkin he can find.

12. You notice a flat open container lying on the beach. There is a small amount of water in the center of the container and a layer of crusty sediment around the water.

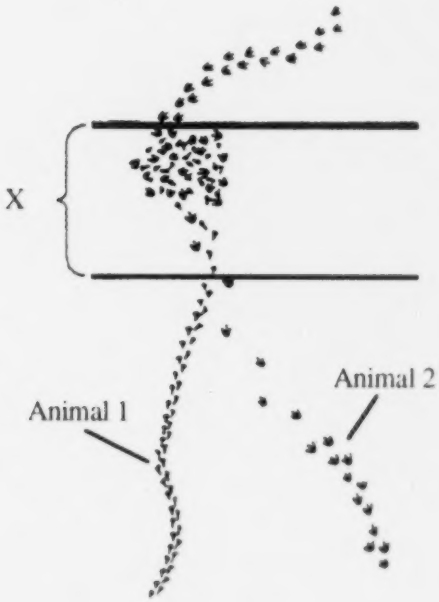
You think the crusty material probably came from evaporation of the water. This is an example of

A. an observation.
B. a hypothesis.
C. a variable.
D. an experiment.

13. Which of the following is an opinion rather than an observation?

A. Many plants are green.
B. Many flowers are beautiful.
C. Plants require sunlight.
D. Plants can grow in different places.

The diagram below represents the fossil evidence of an event that took place far back in the Earth's history.



14. Which of the following probably took place in area X of the diagram?

A. Animal 2 was eaten by Animal 1.
B. Animal 2 flew away.
C. Animal 1 was eaten by Animal 2.
D. Animal 1 stepped in the tracks of Animal 2 when leaving area X.

15. A group of students is told to put 30 fossils into several groups. The students find it difficult to agree on one solution. The main reason that scientists often have the same problem is that

A. fossils have not been studied very much.
B. they work in groups.
C. fossils are very old.
D. there are many different ways to classify fossils.

16. Several students notice that the river running through a park is shallower than it was one week before. One student says that this change must be due to a lack of rain. This statement is best described as

A. a hypothesis that can be investigated.
B. an observation based on theory.
C. a conclusion based on firm evidence.
D. a theory based on experimentation.

17. A student observed a spider and its web. Which of the following is NOT an observation?

A. The web has some threads that are straight.
B. The spider has eight legs.
C. The spider's abdomen is larger than its head.
D. The spider makes no noise.
E. The spider evolved from insects.

18. Jamal has twenty silk worm larvae. Half are 2 centimeters long and half are 4 centimeters long. He knows the length of time it takes the smaller larvae to consume 100 grams of mulberry leaves. Which of the following information should he collect for the 4-centimeter larvae in order to compare the eating rates of the two sets of larvae?

A. Time for all ten larvae to eat 100 grams of leaves
B. Time for each larva to eat on leaf
C. Weight of leaves eaten by all ten larvae in an hour
D. Number of leaves eaten by all ten larvae in a day

19. A computer company want to know how often American eighth-grade students use a computer in earth science class. What is the most efficient way to get this information?

A. Ask all eighth graders in the country
B. Ask some eighth graders in one school district
C. Ask all eighth graders in one state only
D. Ask some eighth graders in 25 states

*20. Measurements taken during a scientific experiment should be both accurate and precise. Accuracy refers to the

A. closeness of the measurements to the true value
B. reproducibility of the measurements
C. location of the measurements taken
D. time between measurements taken
E. number of measurements taken

*21. A scientist develops a theory to explain some phenomena that previous theories could not. However, this theory leads to predictions that are contrary to other scientists' expectations. What should be done in response to these results?

A. Ignore the expectations and accept the theory.
B. Reject the theory since it is contrary to the expectations.
C. Revise the theory so that it agrees with the expectations.
D. Design experiments to test for the predictions made by the theory.
E. Develop another theory that predicts what the scientists expected.

*22. Which of the following statements can be tested most easily?

A. The Earth's temperature in 1997 will be colder than in 1996.
B. Physics is more interesting than biology.
C. DNA is more important than protein.
D. Monkeys are more insightful than cattle.
E. Old seeds are less likely to germinate than new seeds.

*23. While performing an experiment, a scientist finds evidence that a new element exists. Which of the following should the scientist do first?

A. Publish her finding in order to be first.
B. Repeat the experiment using the same conditions.
C. Repeat the experiment, but change one variable to see whether that affects the results.
D. Wait and see whether another scientist finds the same evidence.
E. Look for additional new elements that are similar to the new one.

*24. Which of the following procedures is essential in an experimental study designed to investigate the effects of vitamin K in the diets of humans?

A. Make sure that all the study subjects get the same amount of vitamin K.
B. Use only students as subjects.
C. Use several different brands of vitamin K.
D. Make sure that all study subjects are kept in different environments.
E. Divide the study subjects into experimental and control groups.

*25. Currently, scientists make many predictions about the way solids behave by assuming that the atoms in a solid behave as if they are connected by tiny springs. This means that which of the following is true?

A. There must be tiny springs connecting atoms together.
B. Scientists will always find it useful to think of atoms as connected by springs.
C. An intelligent life form on another planet would almost certainly think about solids in the same fashion.
D. Thinking of atoms as being connected by springs constitutes a useful model of solids.
E. Because it is a successful model, the spring model of the atom can be classified as a fact.

NAEP Questionnaires for Student Views about Scientific Theories and Scientists
(Nature of Science Domain)

Grade Level _____ **Student Number** _____

Teacher _____ **School** _____

1. Gender:	a = female b = male		a b
2. Ethnicity:	a = Asian b = Black c = Hispanic/Latin d = Caucasian e = Native American/Alaskan Native Other (please write in) _____		a b c d e
3. Grade:	a = 6, 7, 8 b = 9 c = 10 d = 11 e = 12		a b c d e

For each question, mark the letter which indicates your view of the most accurate response.

A: How do you feel about each of these statements about scientific theories?

4. It is likely that some theories which scientists use today will be shown to be inadequate someday.	SA	A	N	D	SD
5. Scientists are interested in improving their explanations of natural events.	SA	A	N	D	SD
6. Theories are useful even though they may be incomplete.	SA	A	N	D	SD
7. Scientific theories are important products of science.	SA	A	N	D	SD
8. One important use of a scientific theory is to predict future events.	SA	A	N	D	SD

B: How do you feel about each of these statements about scientists?

9. One very important job of a scientist is to report exactly what he or she observes.	SA	A	N	D	SD
10. Scientists should not criticize each other's work.	SA	A	N	D	SD
11. If a researcher accurately reports his or her experimental results, other researchers should accept the results without question.	SA	A	N	D	SD
12. Once scientists have developed a good theory, they should stick together to prevent others from saying it is wrong.	SA	A	N	D	SD
13. Scientists must be willing to change their ideas when new information becomes known.	SA	A	N	D	SD
14. Different scientists may give different explanations about the same observations.	SA	A	N	D	SD

CHAPTER 8: ASSESSMENT SAMPLES FOR GRADES K-4

These instruments are only examples, and you are encouraged to infuse these ideas into your own experience and to construct more appropriate assessment tasks aligned with your instruction.

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Applied Process Skills and Experimental Design

(Application Domain)

(Adapted from a first grade class in Phoenix, AZ by L. Kellerman)

The question: "which bubble gum sticks to shoes?" was asked in a first grade class in Phoenix Arizona. Students found that gum was sticking to their shoes as they walked into the classroom. They asked their teacher why, so the teacher asked, "how would we study this question?"

The students chose bubble gums of various kinds, and in class discussions agreed on the factors to control:

1. The area of concrete.
2. The length of time to chew the gum.
3. The students designated to be the gum chewers.
4. The shoes used to step on the gum.

Students then had a "gum-chewing period" after which students threw the pieces on a specific area of cement and stepped on them with their shoes. They were trying to discover which gum stuck the most and which the least. The variable considered was the type of gum.

The students used the following data table for organization.

Gum	Minutes chewed	Amount of gum on shoe "sticking strength"
Type #1		
Type #2		
Type #3		
Type #4		
Type #5		
Type #6		

Assessment by the teacher was for the entire class. This assessment included:

_____Did the students provide checks on controls?

_____Did the students use appropriate experimentation skills?

_____Were students' observation skills adequate to determine outcome?

_____Did students discuss results to assure the "correctness" of their choice of "stickiest gum."

_____Were the students enjoying the class investigation?

Sample Application Assessment Items K-3

(Application Domain)

1. **Concept:** Birds hatch from eggs.
   Application Question: You have found some eggs in a nest in a tree. You watch the nest and the eggs hatch. Draw a picture of the kind of animal that you think will come from the eggs. (A picture may be appropriate to elicit students responses.)

2. **Concept**: The continuous movement of water from the land to the air is called the water cycle.
   Application Question: Yesterday you made a mud pie while playing outside. The pie was very runny so you left it outside. If the next day is sunny, draw a picture of what it will look like when you go out to play with it.

3. **Concept**: When resistance is increased, it takes more force to move an object.
   Application Question: Which child is working harder to move the sled?

   (use a picture of a child pulling empty sled)

   (use a picture of a child pulling sled with a child on it)

4. **Concept:** Environments and habitats are all changing. Some changes are a result of natural forces and some are a result of the actions of people.
   Application Question: The flood came through your backyard this summer. Draw a picture of what your back yard looked like before the flood and another picture of your backyard after the flood.

   Before the flood

   After the flood

5. **Concept**: Inches are used for measuring distance.
   Application Question: The teacher has asked you to measure the length of your desk. What unit of measure will you use? Circle the best answer.

   Miles Gallons Inches Pounds

How I feel About Science

Grades K-3

Student Name: _____ Grade Level: _____

Teacher Name: _____ School: _____

After each sentence, place an **X** on the face which indicates your feelings…

SENTENCE	YES	NEUTRAL	NO
1. **Science time is fun.**			
2. **Things I learn in science time help me understand things at home.**			
3. **Science time is not fun.**			
4. **I can do science things now.**			
5. **In science time my teacher likes to have me ask questions.**			
6. **I might want to do a science job when I grow up.**			

Sciencography

(Integrated Domain)

(D. Hall, S. Bartlet, T. Lutz, B. Williams, Grinnell/Marshalltown)

Student name _____ Teacher Name _____

Gender _____ Grade _____ Date _____ School _____

1. To me Science is...

2. Tell about all the ways you use Science in a day.

3. Tell what you like and/or dislike about Science.

4. Someone has said to you that Science is not important. Tell if you agree or disagree with them.

5. If you woke up tomorrow morning and were in the Land of Science, describe what it would be, how you would feel, and what you would do.

I can Measure in Feet!

(Integrated Domain)

(E. Pimlott, United Community School, Boone, Iowa)

By using the following sentences to encourage the positive/celebrating of learning process:

1. I can measure in feet.
2. I can start from the left end of the ruler.
3. I can measure in inches and feet.
4. I can measure 4 things.
5. I can draw a picture of each thing I measured.
6. I can record my measurement under my picture.

Draw A Scientist

(Nature of Science Domain)

(C. Freesmeier, Marquette Primary, Houghton, Iowa)

Purpose: To gain insight into how children view scientists and what they think scientists do.

Preassessment: Ask students to draw a picture of a scientist and show/tell what they think a scientist does.

Postassessment: Ask students to draw a picture of a scientist and show/tell what they think a scientist does. This postassessment could be used at any time, but it may be most useful at midyear or at the end of the year.

Evaluation of the drawings: After the students finish telling or explaining the picture that they draw, help students write/record their ideas about the pictures. Then, you can compare the differences between the preassessment and postassessment pictures to look at changes in students' perceptions.

An "if" to consider: If children hold stereotypic views of scientists and what scientists do, then what will you as the teacher do to change these perceptions?

CHAPTER 9: ASSESSMENT SAMPLES FOR GRADES 5-8

These instruments are teacher-developed examples, and you are encouraged to infuse these ideas into your own experience and to construct more appropriate assessment tasks aligned with your instruction. Student input into the rubric design process is also encouraged.

Assessment Examples

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Evolution of Toys: Back to the Future

(Integrated Domain, Portfolio Task)

Goals: XX = Main Goal X = Related Goal(s)

Skill and Area	Core Concept(s)	Self-Sufficiency	Responsible Group Member	Thinking and Problem Solving	Connecting and Integrating
X	X			X	X X

Core Concept: Model and Scale

Thinking Process: Developing new knowledge

Valued Outcomes: Students use what they already know to learn and acquire new knowledge, develop new skills, or interpret new experiences.

Discipline Area: Interdisciplinary, History

Mode of Presentation: Crafted production, Art form, Media presentation, Written or oral report

Technology : Word processing, Multimedia resources, Internet

Description of Assessment Task:

A major toy company has selected the theme "Evolution of Toys: Back to the Future". You are on a team with four classmates selected by the company as toy designers. Using your experiences with toys and other resources, compare the toys of today with toys of 50 years ago. Using your personal knowledge of how today's toys relate to and affect your experiences, predict what the lives of children were like 50 years ago.

Describe three key differences in the life of a child of the 1940s and your life in the 1990s and summarize your findings in an oral presentation.

Performance Criteria: The extent to which you:

- expand or enhance the meaning of the concept or topic;
- make unique and creative connections;
- make connections to concepts across disciplines;
- involve historical events in different time periods;
- make connections that have personal relevance.

Making Life Easier

(Integrated Domain, Portfolio Task)

Goals: XX = Main Goal X = Related Goal(s)

Skill and Area	Core Concept(s)	Self-Sufficiency	Responsible Group Member	Thinking and Problem Solving	Connecting and Integrating
X	X			X	X X

Core Concept: Model and Scale

Valued Outcome: Students use models and scales to explain or predict the organization, function, and behavior of objects, materials, and living things in their environment.

Discipline Area: Science

Mode of Presentation: Laboratory activity, Oral presentation

Technology: Word processing, Other computer software, Mechanical devices/tools

Description of Assessment Task:

You have watched garbage men pick up garbage cans in your neighborhood. Knowing that they must lift hundreds of garbage cans each day, you intend to make their life easier. To do something about it you plan to design a mechanical device which will lift the can and empty its contents into the garbage truck. Make a working cardboard model of your device, and demonstrate and explain its operation as a machine.

Performance Criteria: The extent to which you:

- conceptualize and build an appropriate working model;
- identify and utilize simple machine(s) in your working model;
- clearly present your oral report.

Applying Concepts of Blood Types

(Application Domain)
(Adapted from GED 1990 by P. Veronesi)

Multiple-choice questions one through five are based on the following information:

In the 1800's blood transfusions were practiced; blood was transferred from one person to another. Sometimes the transfusions were miraculously successful, while at other times persons experienced pain, tingling sensations, and often death. In 1901 a scientific basis was recognized for the successful transfusion of blood. It was realized that blood had to be divided into groups, and only certain types could be transfused successfully to a given individual.

If an incompatible blood type is transfused into a person, the blood cells will clump together in a reaction called agglutination. Agglutination is due to a reaction between antigens and antibodies in the blood. An antigen refers to any substance that produces an immune response; usually the body reacts by producing antibodies. The antibodies attack the antigens, which are recognized as foreign substances.

The best known system of antigens in the blood is the ABO system. The surfaces of red blood cells of blood types A, B, and AB contain certain substances that act like antigens. The safest transfusion of blood takes place when the donor and the recipient have the same type of blood. The most critical factors are the antigens present in the donor's blood and the antibodies present in the recipient's blood plasma. Antigens and antibodies should not "oppose" one another. If the red blood cells containing these antigens are transferred into a person whose blood plasma contains antibodies against them, clumping occurs.

Blood Type	Red Blood Cells Contain	Plasma Contains
A	A antigens	*antibodies against B
B	B antigens	*antibodies against A
AB	A and B antigens	*no antibodies
O	no antigens	*antibodies against A and B

1. At a blood bank there were five problems with a laboratory technologist's work performance the first year at work. Which of the problems listed below would the technician's supervisor likely consider the most serious?

   a. coming to work late
   b. spilling five units of blood
   c. working too slowly
   d. mislabeling four units of blood
   e. breaking the lens on a microscope

2. According to the information presented, the most probable reason some people died in the 1800's after receiving blood transfusion while others recovered is due to

   a. the type of illness the person had
   b. the skill of the physician
   c. how sterile the equipment was
   d. whether the person happened to receive compatible blood
   e. how much blood was lost during the operation

The persons below each received a blood transfusion:

A. a four year old child
B. a middle aged man
C. an elderly woman

3. In which of these people would agglutination probably occur if given the wrong blood type?

   a. A only
   b. B only
   c. C only
   d. A and C only
   e. A, B, and C

4. Which of the following results in agglutination?

   a. similar blood types being mixed
   b. the separation of blood cells from plasma
   c. antigens reacting to other antigens
   d. antibodies reacting to foreign antigens
   e. the donation of blood to a blood bank

5. A "universal receiver" can receive blood cells from persons of any blood type. Which blood type(s) would a person need to have in order to be a "universal receiver"?

   a. A only
   b. B only
   c. AB only
   d. O only
   e. both AB and O only

Personal Video Portfolio

(Integrated Domain, Portfolio)

(C. Jenkins, Visitation Grade School, Stacyville, IA)

Goal: To visually record an individual's growth on projects, presentations, and cooperative learning throughout the year.

Plan: Each student will be required to acquire a video tape to use to record personal projects. Some projects that may be taped: science presentations; activities; learning situations; cooperative group work; other disciplinary work.

The student, teacher, administrator, and parents will be able to view the videos during the year and at the end of the year to assess growth.

These video records can be used to provide feedback and can serve as an excellent record of that student's year.

A sample form of a critique that is sent home with the video is included. The parents and students should view the tape together and discuss and critique the desired specifications.

Video Critique

(Date)

Dear (Parent/Guardian),

I am sending home a video of (_____Insert student's name_____) science presentation for your viewing. Please sit down with your child, and while viewing the video of their presentation, go through the areas that follow and discuss each one. Please include comments for any of the areas. You may use a scale of one to five (five being the highest) to rate the video performance. Focus on the strengths of the performance and also look for areas that are targets for improvement.

Preparation: The student had a well prepared talk. S/he knew what to say about the subject and presented the ideas in a meaningful order. The talk showed evidence of necessary research and planning. Rating: _____
Comments:

_____

_____

Visuals: The student used pictures or visuals to clarify the presentation.
Rating: _____
Comments:

_____

_____

Speaking Clearly: The presentation was delivered in clear speech. The voice was kept at an even pace and at a level that could be heard. The student spoke with expression and showed enthusiasm for the subject. Rating: _____
Comments:

_____

_____

Eye Contact: During the presentation, the student looked at people in the audience and appeared to make eye contact with people. Rating: _____
Comments:

_____

_____

Overall Comments:

_____

_____

The video of the presentation is an exciting way to view each student's progress. Thank you for your cooperation and interest in your child's education. I hope this experience was meaningful for both of you.

Sincerely,

Mrs. Connie Jenkins
Visitation Grade School
Stacyville, IA

Group Assessment of Team Member

(Integrated Domain)

(S. Mikutis, Berg Middle School, Newton, IA)

Desired Outcome: To have students assess how well team/group members worked on a project or task.

Standards for the Criteria

Criteria	Excellent—5	4	Acceptable—3	2	Needs improvement—1
Starts task work	Promptly		Most of the time		Reluctantly
Solves own problems	Almost Always		Most of the time		Seldom
Keeps noise level down	Almost Always		Most of the time		Seldom
Encourages others	Almost Always		Most of the time		Seldom
Participates	Almost Always		Most of the time		Seldom

Possible Tasks:

Group Assessment of Team Members

(Integrated Domain)
(S. Mikutis, Berg Middle School, Newton, IA)

Team Member _____

A. STARTS TASK WORK

5	4	3	2	1
Promptly		Most of the time		Reluctantly

B. SOLVES OWN PROBLEMS

5	4	3	2	1
Almost Always		Most of the time		Seldom

C. KEEPS NOISE LEVEL DOWN

5	4	3	2	1
Almost Always		Most of the time		Seldom

D. ENCOURAGES OTHERS

5	4	3	2	1
Almost Always		Most of the time		Seldom

E. PARTICIPATES

5	4	3	2	1
Almost Always		Most of the time		Seldom

Comments:

Group Project Assessment by Class

(Integrated Domain)

(S. Mikutis, Berg Middle School, Newton, IA)

Desired Outcome: To research, organize, and present to the class, an example of energy transformation/measurement

Standards for the Criteria

Criteria	Excellent—5	4	Acceptable—3	2	Needs Improvement—1
Research References	Used 5 or more references (LMC, classroom, outside) (Primary & Secondary Sources)		Used 3-4 references.		Used fewer than 3 references.
Presentation	Interesting. Good eye contact. Many visual aids. Very well organized		Moderate interest. Some eye contact. Some visual aids. Good organization.		Low interest. Little eye contact. Few visual aids. Poorly organized
Knowledge	Group could answer all questions.		Group was able to answer most questions.		Group was unable to answer most questions.
Relatedness	The project strongly supported our unit on energy transformations.		The project was related to our unit.		The project seemed unrelated and vague.

(A suggestion to improve this rubric would be to add a category which would be indicative of the group's level of conceptual understanding.)

Possible Task:

Group Project Assessment by Class

(Integrated Domain)

(S. Mikutis, Berg Middle School, Newton, IA)

Project Topic _____

Group Name _____

A. RESEARCH

5	4	3	2	1
Used 5 or more references (classroom, outside, resource persons).		Used 3-4 references.		Used fewer than 3 references.

B. PRESENTATION

5	4	3	2	1
Interesting. Good eye contact. Many visual aids. Very well organized.		Moderate interest. Some eye contact. Some visual aids. Good organization		Low interest. Little eye contact. Few visual aids. Poorly organized

C. KNOWLEDGE

5	4	3	2	1
Group could answer all questions effectively.		Group was able to answer most questions.		Group was unable to answer most questions.

D. RELATEDNESS

5	4	3	2	1
The project strongly supported our unit on energy transformations.		The project was related to our unit.		The project seemed unrelated and vague.

Student Self-Assessment For Group Project
(Integrated Domain)
(S. Mikutis, Berg Middle School, Newton, IA)

Desired Outcome: To have students practice and develop self-assessment skills.

Standards for the Criteria

Criteria	Excellent 5	4	Acceptable 3	2	Needs Improvement 1
Research	I used 5 or more references (LMC, classroom, outside) (Primary & Secondary Sources)		I used 3-4 references		I used fewer than 3 references
Contributions	I often helped others with their tasks.		I occasionally helped others with their tasks.		I only had time to work on my own selected tasks.
Social Skills	My group was very easy to work with.		My group was somewhat easy to work with.		My group was difficult to work with.
Task Performance	I completed all my selected tasks on time.		I completed most of my selected tasks.		Some of my task work remained uncompleted.
What I Learned	I learned a great deal about energy.		I learned some things about energy.		I didn't learn much from this energy unit.

Possible Tasks:

Student Self-Assessment For Group Project

(Integrated Domain)

(S. Mikutis, Berg Middle School, Newton, IA)

Name: _____

A. RESEARCH

5	4	3	2	1
I used 5 or more references (LMC, classroom, outside, resource persons)		I used 3-4 references		I used fewer than 3 references

B. CONTRIBUTIONS

5	4	3	2	1
I often helped others with their tasks.		I occasionally helped others with their tasks.		I only had time to work on my own selected tasks.

C. SOCIAL SKILLS

5	4	3	2	1
My group was very easy to work with.		My group was somewhat easy to work with.		My group was difficult to work with.

D. TASK PERFORMANCE

5	4	3	2	1
I completed all my selected tasks on time.		I completed most of my selected tasks.		Some of my task work remained uncompleted.

E. WHAT I LEARNED

5	4	3	2	1
I learned a great deal about energy.		I learned some things about energy.		I didn't learn much from this energy unit.

TOTAL: /25

COMMENTS:

CHAPTER 10: ASSESSMENT SAMPLES FOR GRADES 9-12

These samples are provided as examples, and you are encouraged to infuse these ideas into your own experience and to construct more appropriate assessment tasks aligned with your instruction.

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Student Laboratory Environment Inventory (SLEI)

(Integrated Domain)

Laboratory teaching is one of the unique features of education in the sciences and an integral part of the science classroom. Although a great deal is known about hands-on learning, and many studies have corroborated that learning takes place best when one is "doing science", research has not been comprehensive when it comes to assessing the effects of laboratory instruction upon student learning and attitudes (Fraser, Giddings & McRobbie, 1992). An instrument that has been designed specifically for the science laboratory is the SLEI. The SLEI is intended for use in situations in which a separate laboratory class exists and may be appropriate for secondary and higher education levels.

The SLEI consists of 35 items which are designed to measure five different dimensions and uses the response alternatives of *Almost Never, Seldom, Sometimes, Often,* and *Very Often.* Two SLEI forms can be utilized: An "Actual Form" asks students to note what **actually takes place** in the laboratory classroom whereas the "Preferred Form" asks students to respond to what they would **prefer to take place** in the laboratory class. Teachers interested in administering this assessment instrument should contact the Iowa-SS&C Project at the address listed in the Epilogue of this book.

Looking at Science Processes

Students may be utilizing one or a number of the process skills during an instructional period, and the teacher could use a predetermined observation checklist to observe the groups performing a particular class activity. The checklist can be used to document each student's ability to utilize that process. Some examples of items that could be used to assess some of the processes of science are included in the example. Students should be informed as to what constitutes different performance levels.

Student _____ Date _____

Activity _____ Process(es)_____

Proficient Performance	Limited Proficiency Can use but-Needs More Practice	Cannot do/use-Needs More Instruction and Practice	Not Applicable/ Not Observed
PP	LP	NMI	NA/NO

1.	This student was using appropriate process skills to determine the outcome of the activity.	PP	LP	NMI	NA/ NO
2.	This student performed the process skill(s) within the context of the activity.	PP	LP	NMI	NA/ NO
3.	The process skill(s) enhanced the learning occurring during this activity.	PP	LP	NMI	NA/ NO
4.	This student appropriately noted the performance of the expected process skill in the learning/laboratory log.	PP	LP	NMI	NA/ NO
5.	This student needs additional experiences to practice this _____ skill.	Yes	No		

Recommendations:

Understanding Electricity

(Concept Domain)
(Adapted from Salters Science Project)

1. In a metal wire, an electrical current is caused by moving electrons. Electrons are small particles which are thought

   a. to have a positive charge.
   b.* to have a negative charge.
   c. to be neutral.
   d. to have both a positive and negative charge.

2. The quantity of charge which passes through a circuit is measured in

   a. amps.
   b. volts.
   c.* coulombs.
   d. watts.

3. The amount of energy dissipated each second in a circuit depends on

   a. the voltage only.
   b. the current only.
   c. the resistance only.
   d.* the current and the voltage.

* indicates correct answer

For questions 4-7, four different types of cells are:

   a. zinc/carbon;
   b. lead/acid;
   c. nickel/cadmium;
   d. mercury.

For each of the following items, choose the letter of the most suitable cell to use.

4. A hearing aid (d)
5. A model car (a)
6. A real car (b)
7. A rechargeable electric shaver (c)

8. Draw circuit diagrams for each of these situations:

   a. A battery of three cells is used to supply two bulbs connected in parallel.
   b. A single cell is used to supply two bulbs in series. A voltmeter is connected across one of the bulbs to measure the potential drop across the bulb.

Understanding Temperature and Heat

(Concept Domain)
(Adapted from C. Guo)

Check whether each statement is true or false. If you are not sure whether the statement is true or false, check "I'm not sure."

1. Temperature is the quantity of heat that is absorbed by an object.

   True ____ False _____ I'm not sure _____

2. When heat is absorbed by an object, its temperature always increases; when heat is released by an object, its temperature always decreases.

   True ____ False _____ I'm not sure _____

3. Temperature is a physical property of a substance; some substances are cold; some are warmer.

   True ____ False _____ I'm not sure _____

4. Things left inside a container for a long time will all reach the same temperature.

   True ____ False _____ I'm not sure _____

5. If the temperature of an object which is heated remains the same, then there is probably a change in the state of the object.

   True ____ False _____ I'm not sure _____

6. A larger piece of ice has a lower temperature than a smaller one, therefore it melts slower.

   True ____ False _____ I'm not sure _____

7. Temperature is a kind of energy; higher temperature objects contain more heat and lower temperature objects contain less heat.

   True ____ False _____ I'm not sure _____

   Please write down other things you know or do not know about temperature or heat.

Understanding Environmental Sciences

(Concept Domain: Adapted from George R. Fleetwood)

Select the best answer.

1. In a biotic community made up of clover, rabbits, and foxes, the most immediate effect of an extended drought in the area would be:

   a. a decrease in foxes.
   b. a decrease in rabbits.
   c. a decrease in clover.
   d. an increase in rabbits.

2. The number of different species of birds, insects, and mammals, occupying a given ecosystem is primarily dependent upon:

   a. the amount of competition between species.
   b. the diversity of vegetation in the system.
   c. the absence of large predators.
   d. the time when vegetation is the thickest.

3. Identify the type of area that would have these plants and animals: Caribou; lemmings; lichens; moss; short grass; wolves.

   a. the North American tundra
   b. a Zoo
   c. the eastern deciduous forest
   d. the southwestern desert
   e. a tropical rain forest

4. What would immediately happen if the producers in an ecosystem were suddenly unable to utilize radiant energy from the sun?

   a. Respiration in producers would suddenly cease.
   b. Photosynthetic activity would stop.
   c. The system would increase its biomass.
   d. The decomposers in the system would cease to function.

5. What is the relationship between:
   (1) the number of producers in an ecosystem and
   (2) the number of primary consumers in the same system?

   a. An increase in (1) is usually accompanied by an increase in (2).
   b. An increase in (1) is usually accompanied by a decrease in (2).
   c. (1) and (2) are unrelated.
   d. (1) is dependent on (2).

Applying Concepts of Heat

(Application Domain)

(Adapted from an instrument developed by teachers in Mason City, Iowa)

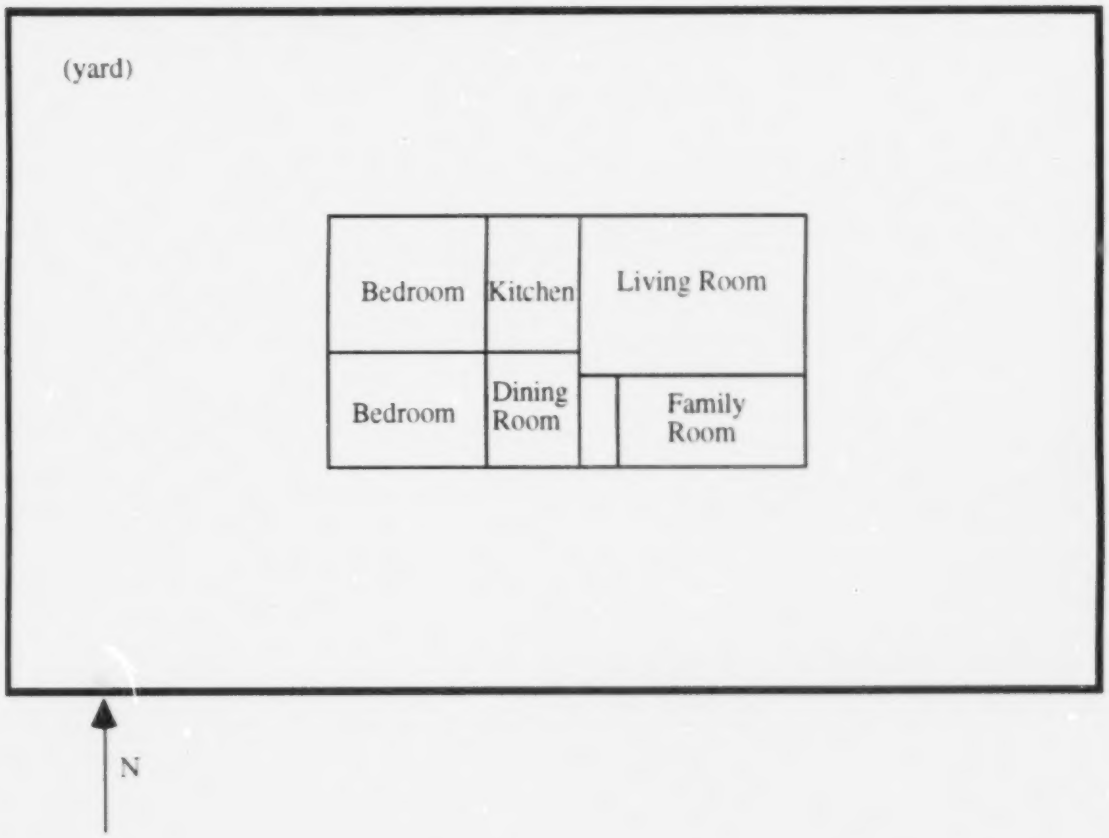
Heat Transfer:

1. Draw a picture of an ice cube and a flaming candle. Label with arrows to show the direction(s) of heat flow. (concept)

Note: Since there are numerous ways in which this could be drawn, a drawing could be provided and students could label and also describe the situation.

Urban Habitat:

2. Look at the blueprint of the house provided. Show where you would locate trees for the best energy conservation (cooling and shade in summer, wind protection in winter). Briefly explain why you selected the location(s). (concept/application/creativity)



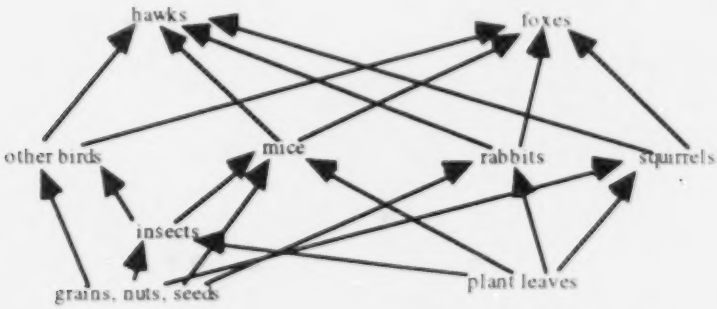
Applying the Concepts of Food

(Application Domain)
(Adapted from GED 1990 by P. Veronesi)

The passing of energy in the form of food from one organism to another is called the food chain. The producers begin the chain by capturing the sun's energy to produce their own food. Then consumers eat the producers to obtain their energy. Consumers may also eat other consumers.

The following diagram is an example of a food chain:

A food web demonstrates the feeding patterns in a given ecosystem. The following diagram is an example of a food web.



1. When a large group of cats was introduced to the food web shown, almost all of the mice were consumed in just a few weeks. Which population most likely showed the largest increase in population?

   a. insects
   b. foxes
   c. rabbits
   d. hawks
   e. squirrel

2. Not illustrated in this food chain are the decomposers, organisms that obtain their food from both wastes and dead organisms. Decomposers are important in the food chain because they

   a. recycle nutrients.
   b. inhibit diseases.
   c. control population growth.
   d. compete with producers.
   e. compete with consumers.

3. The food web shown is hypothetical. In reality, it could be expected that food webs would be

   a. very similar to the illustration.
   b. more complex than the illustration.
   c. simpler than the illustration.
   d. uncommon in nature.
   e. nonexistent in nature.

4. Which of the following statements is <u>incorrect</u> based upon the information provided?

   a. Each level of the food chain depends on the level below.
   b. Energy travels in both directions in a food chain
   c. The food web shows many interrelated food chains.
   d. Consumers often compete for the same food source.
   e. Most consumers eat a variety of foods.

5. Which of the following would be considered a producer in the ocean?

   a. shrimp
   b. mussels
   c. algae
   d. salt
   e. whales

6. Consumers in the food chain are ranked according to

   a. their size.
   b. their weight.
   c. where they live.
   d. what they eat.
   e. how much they eat.

Self-Analysis Questionnaire: Form 1

(Attitude Domain)

Directions: A number of statements that people use to describe themselves are given. Read each statement and then blacken the appropriate space on the answer sheet to indicate how you feel right now. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to best describe your present feelings.

Ax: S-Anxiety
Cy: S-Curiosity
Ag: S-Anger
(-): Reverse Score

					Not at all	Some-what	Moder-ately	Very Much
Ax-			1.	I feel calm.	1	2	3	4
	Cy+		2.	I feel like exploring my environment.	1	2	3	4
		Ag+	3.	I am furious.	1	2	3	4
Ax+			4.	I am tense.	1	2	3	4
	Cy+		5.	I feel curious.	1	2	3	4
		Ag+	6.	I feel like banging on the table.	1	2	3	4
Ax-			7.	I feel at ease.	1	2	3	4
	Cy+		8.	I feel interested.	1	2	3	4
		Ag+	9.	I feel angry.	1	2	3	4
Ax+			10.	I am presently worrying over possible misfortunes.	1	2	3	4
	Cy+		11.	I feel inquisitive.	1	2	3	4
		Ag+	12.	I feel like yelling at somebody.	1	2	3	4
Ax+			13.	I feel nervous.	1	2	3	4
	Cy+		14.	I am in a questioning mood.	1	2	3	4
		Ag+	15.	I feel like breaking things.	1	2	3	4
Ax+			16.	I am jittery.	1	2	3	4
	Cy+		17.	I feel stimulated.	1	2	3	4
		Ag+	18.	I am mad.	1	2	3	4
Ax-			19.	I am relaxed.	1	2	3	4
	Cy+		20.	I feel mentally active.	1	2	3	4
		Ag+	21.	I feel irritated.	1	2	3	4
Ax+			22.	I am worried.	1	2	3	4
	Cy-		23.	I feel bored.	1	2	3	4
		Ag+	24.	I feel like hitting someone.	1	2	3	4
Ax-			25.	I feel steady.	1	2	3	4
	Cy+		26.	I feel eager.	1	2	3	4
		Ag+	27.	I am burned up.	1	2	3	4
Ax+			28.	I feel frightened.	1	2	3	4
	Cy-		29.	I feel disinterested.	1	2	3	4
		Ag+	30.	I feel like swearing.	1	2	3	4

Self-Analysis Questionnaire: Form 2

Directions: A number of statements that people use to describe themselves are given below. Read each statement and then blacken the appropriate space on the answer sheet to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you *generally* feel.

Ax: T-Anxiety
Cy: T-Curiosity
Ag: T-Anger
(-): Reverse Score

					Almost Never	Some-times	Often	Almost Always
Ax-			31.	I am a steady person.	1	2	3	4
	Cy+		32.	I feel like exploring my environment.	1	2	3	4
		Ag+	33.	I am quick tempered.	1	2	3	4
Ax-			34.	I feel satisfied with myself.	1	2	3	4
	Cy+		35.	I feel curious.	1	2	3	4
		Ag+	36.	I have a fiery temper.	1	2	3	4
Ax+			37.	I feel nervous and restless.	1	2	3	4
	Cy+		38.	I feel interested.	1	2	3	4
		Ag+	39.	I am a hotheaded person.	1	2	3	4
Ax+			40.	I wish I could be as happy as others seem to be.	1	2	3	4
	Cy+		41.	I feel inquisitive.	1	2	3	4
		Ag+	42.	I get angry when I'm slowed down by others mistakes.	1	2	3	4
Ax+			43.	I feel like a failure.	1	2	3	4
	Cy+		44.	I feel eager.	1	2	3	4
		Ag+	45.	I feel annoyed when I am not given recognition for doing good work.	1	2	3	4
Ax+			46.	I get in a state of tension or turmoil as I think over my recent concerns and interests.	1	2	3	4
	Cy+		47.	I am in a questioning mood.	1	2	3	4
		Ag+	48.	I fly off the handle.	1	2	3	4
Ax-			49.	I feel secure.	1	2	3	4
	Cy+		50.	I feel stimulated.	1	2	3	4
		Ag+	51.	When I get mad, I say nasty things.	1	2	3	4
Ax+			52.	I lack self-confidence.	1	2	3	4
	Cy-		53.	I feel disinterested.	1	2	3	4
		Ag+	54.	It makes me furious when I am criticized in front of others.	1	2	3	4
Ax+			55.	I feel inadequate.	1	2	3	4
	Cy+		56.	I feel mentally active.	1	2	3	4
		Ag+	57.	When I get frustrated, I feel like hitting someone.	1	2	3	4
Ax+			58.	I worry too much over something that really does not matter.	1	2	3	4
	Cy-		59.	I feel bored.	1	2	3	4
		Ag+	60.	I feel infuriated when I do a good job and get a poor evaluation.	1	2	3	4

An Individual View of the Way Science Happens

(Nature of Science Domain: Adapted from Cooley & Klopfer)

Grade Level _____ **Student Number** _____

Teacher _____ **School** _____

1. Gender:	a = female b = male		a b
2. Ethnicity:	a = Asian b = Black c = Hispanic/Latin d = Caucasian e = Native American/Alaskan Native Other (please write in) _____		a b c d e
3. Grade:	a = 6, 7, 8 b = 9 c = 10 d = 11 e = 12		a b c d e

For each question, mark the letter which indicates your view of the best response.

Correct answers are indicated by an asterisk (*).

4. The main reason that scientists study plants is

   A. to teach farmers how to grow more food.
   B. to learn how to make better medicine from plants.
   C.* to be able to explain how plants grow.
   D. to be able to tell what is the best soil for plants.

5. Over 200 years ago, a scientist, Sir Isaac Newton, explained the motion of planets with what is called "gravity". Scientists decided that Newton's explanation was right. Not long ago a scientist, Albert Einstein, said that his idea ("relativity") could explain everything that Newton's idea ("gravity") could explain, plus more. Today, scientists accept Einstein's idea ("relativity"). What do they say that Newton's idea?

   A. Newton's idea was wrong, but Newton didn't study as many things as Einstein did.
   B.* Newton's idea was right, but Newton's idea can't explain as much as Einstein's idea can.
   C. Newton's idea will only work if you are on a planet somewhere else in space.
   D. Newton's idea is better than Einstein's because it has been used longer.

6. A scientist in Australia says that she has seen signs of plant life on the planet Venus. American scientists will believe this scientist

   A.* if other scientists also see these signs of plant life.
   B. if she can tell them what type of plants these probably are.
   C. if the Australian government will stand behind the scientist's work.
   D. if other scientists agree that there is oxygen on Venus.

7. If we ask an astronomer to explain why some stars look brighter than others, his explanation would

A. tell us why it is necessary for stars to be different in brightness.
B.* use scientific laws.
C. be made with mathematical equations and formulas.
D. use observations and data from astronomy.

8. Science is an attempt to

A. make sure that what has been discovered about the world is really true.
B.* give us laws and theories that explain nature.
C. discover, collect, and group facts about nature.
D. find ways to make people's lives better.

9. Which of these statements best describes scientific knowledge?

A. Scientific knowledge is a well-organized collection of facts.
B.* Today's scientific knowledge builds on data and ideas from the past.
C. Today's scientific knowledge has been produced by today's scientists.
D. Scientific knowledge contains only statements that are 100% true.

10. Are biology, chemistry, and physics related to each other?

A. They are not related, because they are built on different basic ideas.
B.* They are related, because some of the ideas in each relates to the ideas in the other two.
C. They are related, because mathematics ties them together.
D. They are not connected, because each one studies something very different from what is studied by the other two.

11. Today scientists are doing experiments to see if one of Einstein's theories is right when it predicts that light rays will bend as they pass near a very large object such as a star. This is an example of

A.* how theories suggest experiments to do.
B. how it is important to have an exact measurement of how fast light travels.
C. how experiments must be done in order to prove that a theory is really true.
D. how theories are still doubted long after they are proven true.

12. Designing a television set is a problem for

A. science, because to design it you need brain power.
B. science, because to design it you need to do experiments.
C.* technology, because it leads to a useful device.
D. technology, because it involves working with electricity.

13. Betty is planning an experiment to find out whether potassium is important in the growth of a certain plant. Her teacher suggests growing one group of these plants in soil with nitrogen and phosphorus, but no potassium. The teacher will probably also suggest that Betty grow another group in soil with

A. potassium only.
B.* nitrogen, phosphorous, and potassium.
C. nitrogen and potassium, but not phosphorus.
D. nitrogen and phosphorus, but not potassium.

14. All of the following statements deal with how science and technology are connected. Which statement best describes the connection?

A.* Technology uses scientific knowledge to help it solve practical problems.
B. Science depends on technology for ideas and for help in planning experiments.
C. The laws used in science come from technology.
D. Technology is the part of science that solves mechanical problems.

15. John is asked to describe a scientific law. Which of the following descriptions should he give?

A. A scientific law is an exact report of what scientists observe.
B.* A scientific law says how one sort of event in nature is related to another event.
C. A scientific law is an explanation of an event in nature and it uses things that can't be seen.
D. A scientific law is a rule that nature makes and it cannot be broken.

16. A certain law can't explain some of the facts that it should explain. What may scientists do with this law?

A. Scientists may change the unexplained facts so that the law can explain them.
B.* Scientists may change the law so that more of the facts can be explained.
C. Scientists should throw out the law and make a new one immediately.
D. Scientists should show that the law is wrong in the case of all facts.

17. Robert Hooke did many experiments with springs and found that most springs stretch by twice as much when the amount of weight hung on the spring is made twice as great. Springs stretch by three times when the amount of weight is made three times as great, and stretch four times as much when four times as much weight, etc. This led Hooke to make a general rule for how much springs stretch when different weights are hung from them. This story is an example of how some scientists have

A. come up with a scientific theory.
B. tested a scientific hypothesis.
C.* come up with a scientific law.
D. come up with ideas about real things from ideas about imaginary things.

18. When a new theory is suggested, scientists will probably decide that it is a good theory

A. if they think the theory is true.
B. if the theory can be put into a mathematical equation.
C. if the theory fits with what they observe and agrees with their other ideas.
D.* if the theory fits with observations.

19. When scientists decide that a new theory is a good theory, we can say that:

A.* Science's ideas and explanations of nature have grown.
B. One more of nature's laws is now known.
C. We are closer to the end of the search for scientific knowledge.
D. Science has discovered new experimental evidence.

20. Many people say that scientists behave in special ways. For example, they observe carefully; they don't jump to conclusions; and they are very exact. If we wanted to see scientists behave this way, it would be best to watch them when they are

A.* doing experiments.
B. doing work outside of science.
C. doing almost anything.
D. with their family and friends.

21. In discussing the problem of nuclear weapons, a famous scientist said that we must keep on doing experiments with nuclear bombs. The scientist is probably

A. right, because his scientific attitude makes his answers to problems more correct.
B. wrong, because scientists seem to be trying to destroy the world.
C. right, because scientific results are right more often than other kinds of results are.
D.* no more right or wrong than any other intelligent person, unless he has studied the problem.

22. A book about science says, "Scientists do experiments to ask nature questions." This means that experiments are used in science

A. to prove that nature follows rules.
B. to learn by trying different solutions to a problem until one works.
C.* to see if predictions made from scientists' ideas are right.
D. to try to find out where humans came from.

23. John has a good imagination, but he may never become a scientist because

A. he would not want to give up being able to think anything that he wants to.
B. people with a good imagination usually become artists and writers.
C.* he might like some other field better than science.
D. science has too many facts.

24. When scientists carefully measure any quantity many times, they expect that

A. all of the measurements will be exactly the same.
B. only two of the measurements will be exactly the same.
C. all but one of the measurements will be exactly the same.
D.* most of the measurements will be close but not exactly the same.

25. What is a scientific theory?

A. It uses arithmetic.
B. It describes a scientist.
C. It describes an experiment.
D.* It explains why some things act the way they do.

What You Think About the Nature of Science

(Nature of Science Domain)

Grade Level _____ **Student Number** _____

Teacher _____ **School** _____

1. Gender:	a = female b = male		a b
2. Ethnicity:	a = Asian b = Black c = Hispanic/Latin d = Caucasian e = Native American/Alaskan Native Other (please write in) _____		a b c d e
3. Grade:	a = 6, 7, 8 b = 9 c = 10 d = 11 e = 12		a b c d e

For each question, mark the letter which indicates your view of the best response.

	Strongly Agree	Moderately Agree	Mildly Disagree	Strongly Disagree
4. Science means questioning, explaining, and testing.	a	b	c	d
5. Science means studying the concepts developed and known by scientists.	a	b	c	d
6. Science means working with various objects and materials in classrooms and laboratories.	a	b	c	d
7. Science deals with activities that affect living, i.e., in home, schools, communities, and nations.	a	b	c	d
8. Science is a human activity that involves acting upon questions about the universe.	a	b	c	d
9. Science is a body of knowledge, developed over years, about the universe.	a	b	c	d
10. Science can be defined by what scientists know.	a	b	c	d
11. Science is an attempt to know more about the world around us.	a	b	c	d
12. Science is a way of viewing the universe and how it works.	a	b	c	d

13. Science is based on curiosity about objects and events in the universe.	a	b	c	d
14. Science is based on attempts to answer the questions about the objects and events in the universe.	a	b	c	d
15. Science must include tests in nature that illustrate the validity of personal explanations offered.	a	b	c	d
16. Science is a self-correcting human endeavor.	a	b	c	d
17. Any theory or concept of science can be challenged.	a	b	c	d

Glossary

Assessment—The key questions are: What do students know? How well do teachers teach? Do our schools work? (Kulm & Malcom, 1991).

alternative assessment applies to assessments that differ from the multiple-choice, timed, one-shot approaches that characterize most standardized and many classroom assessments (Marzano et al., 1993). The reason to promote using alternative assessment is to avoid the drawback of ignoring other performances in addition to outcomes coming from standardized tests.

authentic assessment conveys the idea that assessment should engage students in applying knowledge and skills in the way they are used in the real world. The key point is "test students in context" rather than by using the standardized tests. It also reflects good instructional practice, so that teaching to the test is desirable (Wiggins, 1989).

holistic assessment is "whole student" assessment. This approach stresses the totality of student performance in the classroom. Like the performance assessment, it emphasizes that the outcomes of tests are not the ultimate goal of instruction. Actually, an excellent way to evaluate student work in the lab or in the class is to keep records of observations the teacher makes. Observations help the teacher determine which student "appears to be having difficulty, who has problems using the hand lens and the scales, who contributes interesting ideas, who hangs back, and so on" (Raizen & Kaser, 1989).

performance assessment refers to the variety of tasks and situations in which students are given opportunities to demonstrate their understanding and to thoughtfully apply knowledge, skills, and habits of mind in a variety of contexts (Marzano et al., 1993).

Application Domain—The key question is to what extent students can transfer and use effectively what they have learned in a new situation, especially in daily life (Gronlund, 1988). STS stresses the association of scientific knowledge with students' social and living experiences by using current social issues to help students see their connections. Starting from the concerns in the real world may be a way to diminish the learning gap between the two worlds: the school-science experiences; the personal technology experiences (Yager & McCormack, 1989).

Attitude Domain—A state of mind or a feeling. The term is very broadly used in discussions about science education, but often in various meanings. It is possible to distinguished two broad categories: attitude toward science (e.g., "interest in science", "attitude toward scientists", or "attitudes toward social responsibility in science"); scientific attitude. (i.e., "open-minded", "honesty", or "skepticism") (Gardner, 1975). While Science for All Americans postulates scientific literacy for all Americans, STS curriculum tries to promote students' positive attitude toward science which includes an I-can-do-it attitude and decision-making about social and environmental issues (Yager & McCormack, 1989).

Behaviorist Teaching Approach—"The goal...is to determine how instructional manipulations affect changes in behavior. Thus the main question here is: What is the relationship between instructional manipulations and outcome performance?" (Mayer, 1987).

Cognitive Teaching Approach—The cognitive approach attempts to understand how instructional manipulations affect internal cognitive processes such as paying attention; how these processes result in the acquisition of new knowledge; and how new knowledge influences performance, such as on tests. The goal is to explain the relation between stimulus and response by describing the intervening cognitive processes and structures (Mayer, 1987).

Concept Domain—Conceptual systems are primarily structured via *kind* or *is-a* hierarchies (i.e., Tweety is a canary, which is a kind of bird, which is a kind of animal, which is a kind of thing) and *part-whole* hierarchies (i.e., a toe is part of a foot, which is part of a leg, which is part of a body) (Thagard, 1992). Helping students to construct the natural world into their own categorization in terms of scientific knowledge is one of the basic functions of science education. This domain includes facts, laws (principles), theories, and internalized knowledge of students (Yager & McCormack, 1989).

Concept Mapping—A technique for externalizing concepts and propositions. Propositions are two or more concept labels linked by words in a semantic unit. Concept maps are an explicit, overt representation of the concepts and propositions a person holds, they allow teachers and learners to exchange views on why a particular prepositional linkage is good or valid, or to recognize missing linkages between concepts (Novak & Gowin, 1984). It is always used with interview to sort out the underlined meaning of each proposition.

Constructivism—In short, "The learner constructs meaning in terms of his/her existent experiences in a social context". (1) Knowledge is not passively received, but is actively built up by the person's passed experiences. (2) The function of cognition is adaptive and serves in the organization of the experiential world, not the discovery of ontological reality; meaning: we do not find truth but construct viable explanations from our experiences (Wheatley, 1991).

Cooperative Learning—It could be argued that students should learn through discussion in a social contexts. Personal learning cannot be independent from external social activities. When students work in a small groups they are stimulated by challenges to their ideas and thus recognize the need to reorganize and re-conceptualize (Haste, 1987). Actually, Johnson & Johnson (1990) showed that when students learn more social skills, their performance on standardized Math computation scales is better.

Creativity Domain—As Penick (1992) quoted in his "STS Instruction Enhances Student Creativity", Torrance (1974) described creativity as "...the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and re-testing these hypotheses and possibly modifying and re-testing them; and finally communicating the results." STS teaching strategies stress the role of guessing as the basic element of creativity and suggests that students give wild guesses to serve as a diversity of perspectives in seeing the same natural phenomena to stimulate students' creativity and interpretation of results (Yager & McCormack, 1989).

Evaluation—Statistically speaking, it is the systematic process of collecting, analyzing, and interpreting information for judging decision alternatives. It not only contains quantitative measurements, but also involves a "value" judgment. Practically used in the classroom, it is the process of interpreting students' performances on a test such as multiple choice questions, or the standards such as rubrics teachers set under certain contexts.

Informal Test—A test constructed by a teacher for use in one or a limited number of occasions where comparability or results across groups is not essential.

Law—Laws are often expressed as equations relating measurable parameters. Laws indicate the mathematical relations which hold among quantities of certain empirical parameters. Laws provide us with knowledge of facts, but not with an explanation as to why the facts are as they are (Dilworth, 1981).

Measurement—The process of assigning numbers to attributes of individuals according to specified rules (always refers to quantification).

Nature of Science Domain—STS stresses the nature of the development of scientific knowledge and the influence coming from the external social factors which in turn discount the absolute objectivity of science. The basic themes are as follows (Abimbola, 1983):

1. Observations are theory-loaded.
2. Paradigms determine what problem to solve, what instruments to use, and what inferring techniques and models to employ.
3. Formal logic is rejected as the primary tool for the analysis of science and replaced by a reliance on the detailed study of the history of science. The ultimate decision on scientific question rests with the scientific community.
4. Continuing research coupled with continuing criticism, rather than accepted results are the core of science.
5. Science has two phases: normal science and revolutionary science. Normal science operates under a shared paradigm and is responsible for causing scientific revolutions. The most import events in the history of science are revolutions which change paradigms. Progress in science is therefore non-cumulative.
6. Observational data do not remain the same from one scientific revolution to another…because scientific paradigms are incommensurable.

As Lederman (1992) suggested, students' conception of the nature of science was inadequate, and Carey et al (1989) suggested that the teaching of the nature of science can improve learning. As some of researchers suggested (Matthews, 1991), historical case study may be one of the ways to lead students into certain time-space circumstances to facilitate more understanding of the nature of science.

Process Domain—Practical work including hands-on activities, scientific inquiries, or experiments is always accounted as the most powerful approach to helping students understand scientific knowledge. At the same time, Hodson (1992) argued that the skilled-based approach of practical work was philosophically unsound, educationally worthless, and pedagogically dangerous. STS suggests a holistic view of assessment to promote valid process-learning, especially emphasizing the role of creativity in the data-analysis process (*Exploring and discovering* in Yager & McCormack, 1989).

Reliability—Consistency or the degree of consistency between two or more measures of the same thing. The key questions are: "are the performances of students consistent?"; "to what degree?" High reliability of a test doesn't necessarily indicate a good measurement unless there is also high validity.

Rubrics/Scoring Guides—are used to score non-traditional assessments. A typical rubric contains anywhere from three to ten levels of performance, states all the major dimensions to be assessed, and provides necessary information about idiosyncrasies in the question or equipment. Holistic, analytic, or component rubrics can be used.

Scientific Inquiry—The process in which students investigate the phenomena and interpret the results of their observations. In a positivist viewpoint, students can reach the scientific knowledge without help from external guidance. Yet, more and more research confirms that students' prior knowledge may bias what they observe and create misconceptions (Matthews, 1988). Like Ausubel said, "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (1968).

Standardized Test—A test constructed for use in more than one setting. It is standardized in the sense that the administrative procedures, directions, apparatus, and scoring are fixed by the constructors so that the test may be administered and scored identically by different examiners in different settings to achieve comparable results across all examined.

Test—A systematic procedure for observing behavior and describing it with the aid of numerical scales or developed categories.

Theory—The primary function of theories is to provide the conception of a mechanism which can explain the empirical regularities behind appearances, as do laws. Yet theories may simply offer potentially true descriptions of a reality. Thus, a theory can one day come to be abandoned as a result of measurement made by ever more sensitive instruments, or the arrival of a superior alternative (Dilworth, 1981).

Validation—The process by which a test user collects evidence to support the types of inferences that are to be drawn from test scores (Crocker & Algina, 1986, p. 217).

Validity—The degree to which the test actually measures what it purports to measure (Anastasi, 1982, page 28). The key questions are "do we test what we want to test?" and "to what degree?" High validity usually indicates high reliability.

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Epilogue

This handbook is a source of ideas, inspiration, and guidance in assessment for students, teachers, parents, and administrators. As Hein and Price (1994) stated:

> *"Education is a real-world activity, engaged in by real students, teachers, and administrators in a complex, changing, and challenging world. There can be no perfect education in practice, and there is therefore no perfect assessment. Nor can assessments be free of values. All we can hope is continually to strive to achieve our educational goals, to learn from our failures, and to provide the best possible education for the children in our care. One part of this effort involves continually improving assessment."*

To improve assessment, teachers are encouraged to contribute to this handbook by sending assessments they have developed for use in their classrooms. Examples are welcome and, if included in future editions of this handbook, will be credited to the contributing author(s). As the assessment handbook evolves, instruments and alternative forms of assessment contributed by teachers will add to the process of change that is occurring in assessment during the 1990's and into the millennium.

Comments, suggestions, and examples of assessment can be sent to The Assessment Handbook at the following addresses.

Suggestions may be submitted to:

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